

**THE ARCHAEOLOGY OF
CARIBBEAN AND CIRCUM-CARIBBEAN
FARMERS 6000 BC–AD 1500**

EDITED BY BASIL A. REID

The Archaeology of Caribbean and Circum-Caribbean Farmers (6000 BC–AD 1500)

Comprising 17 chapters and with a wide geographic reach stretching from the Florida Keys in the north to the Guianas in the south, this volume places a well-needed academic spotlight on what is generally considered an integral topic in Caribbean and circum-Caribbean archaeology.

The book explores a variety of issues, including the introduction and dispersal of early cultivars, plant manipulation, animal domestication, dietary profiles, and landscape modifications. Tried-and-true and novel analytical techniques are used to tease out aspects of the Caribbean and circum-Caribbean database that inform the complex and often-subtle processes of domestication under varying socio-environmental conditions. Contributors discuss their findings within multiple constructs such as neolithisation, social interaction, trade, mobility, social complexity, migration, colonisation, and historical ecology. Multiple data sources are used which include but are not restricted to rock art, cooking pits and pots, stable isotopes, dental calculus and pathologies, starch grains, and proxies for past environmental conditions.

Given its multi-disciplinary approaches, this volume should be of immense value to both researchers and students of Caribbean archaeology, biogeography, ethnobotany, zooarchaeology, historical ecology, agriculture, environmental studies, history, and other related fields.

Basil A. Reid (PhD, University of Florida) is Professor of Archaeology in the Department of History at The University of the West Indies, St. Augustine, Trinidad and Tobago. He is currently the senior representative for Central America and the Caribbean at the World Archaeological Congress. His major research interests are the pre-colonial archaeology of the Caribbean, archaeology and geoinformatics, precolonial Caribbean farmers and Caribbean heritage. He has published in a variety of peer-reviewed journals, and has authored, edited and co-edited several books on a variety of topics relating to Caribbean archaeology. His books include *Archaeology and Geoinformatics: Case Studies from the Caribbean* (2008), *Myths and Realities of Caribbean History* (2009), *Caribbean Heritage* (2012) and *Encyclopedia of Caribbean Archaeology* (2014). He is a member of the editorial boards of

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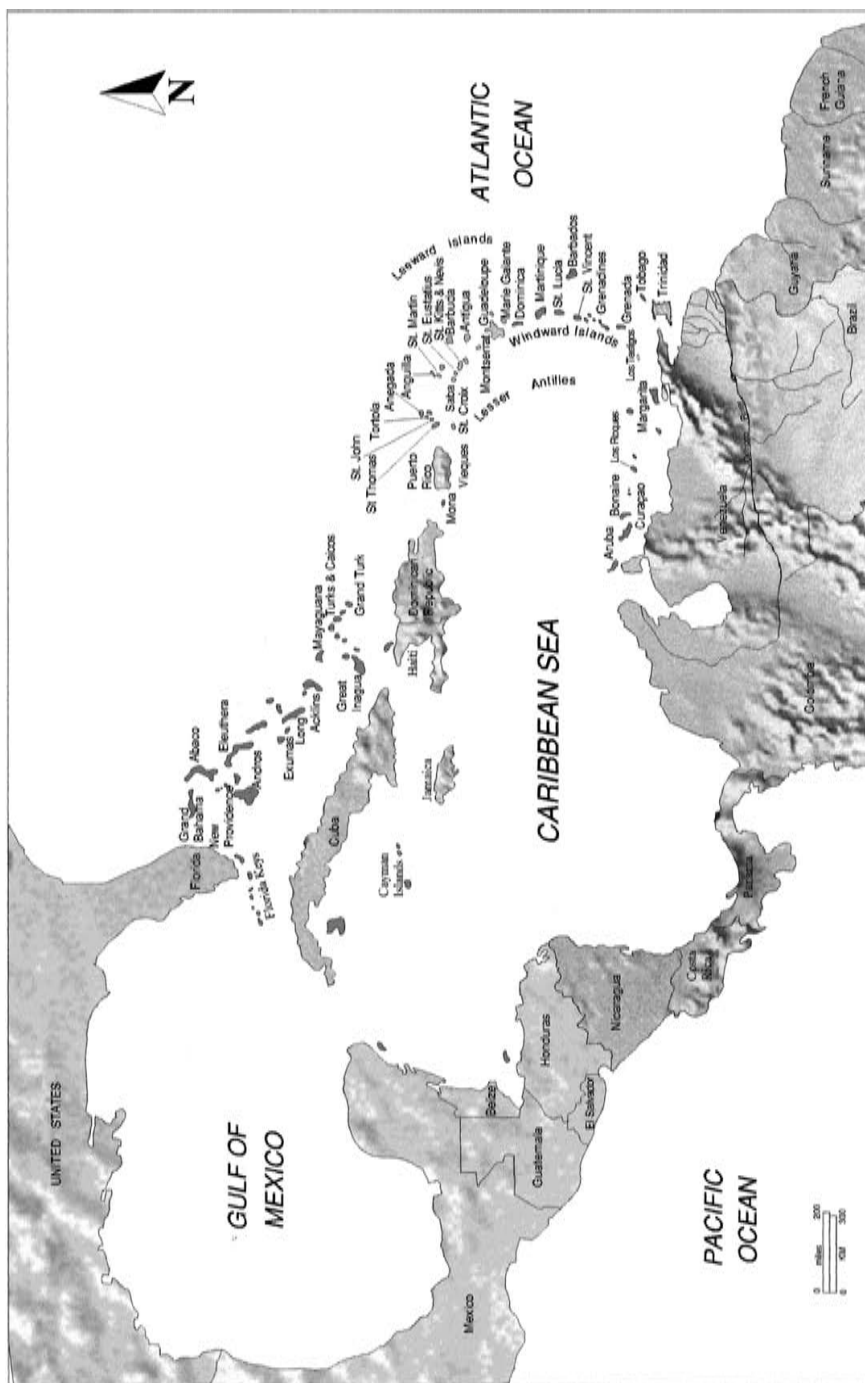
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Basil A. Reid





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Caribbean and circum-Caribbean farmers

An introduction

Basil A. Reid, Peter E. Siegel, Nicholas P. Dunning, Corinne L. Hofman, Stéphen Rostain, Victor D. Thompson, and Scott M. Fitzpatrick

This book is devoted to the archaeological study of precolonial farmers in the Caribbean and circum-Caribbean. Comprising 17 chapters, with a wide geographic reach stretching from the Florida Keys in the north to the Guianas in the south – with most of the discussion focused on the insular Caribbean – this volume places well-needed academic spotlight on what is generally considered an integral topic in Caribbean and circum-Caribbean archaeology.

The chapters in this book span the full sweep of human history in the Caribbean and somewhat less than all of human history in the circum-Caribbean region. Much of the narrative in the book revolves around a variety of issues, including the introduction and dispersal of early cultivars, plant manipulation, animal domestication, dietary profiles, and landscape modifications. Tried-and-true and novel analytical techniques are featured in teasing out aspects of the Caribbean and circum-Caribbean database that inform on the complexities and often-subtle processes of domestication under varying socio-environmental conditions. Authors discuss their findings within multiple constructs such as neolithization, social interaction, trade, mobility, social complexity, migration, colonization, and historical ecology. Multiple data sources are used which include but are not necessarily restricted to rock art, cooking pits and pots, stable isotopes, dental calculus and pathologies, starch grains, and proxies for past environmental conditions.

When this book was first conceptualized, it was decided at the outset not to narrowly focus on the insular Caribbean but to also include both the circum-Caribbean and the Florida Keys. This approach was guided by several considerations. The zone along the Caribbean coast of Colombia, Venezuela, Guyana, Suriname, and French Guiana is considered important for Caribbean archaeology because the majority of early Caribbean indigenous peoples (the Ortoiroid, Saladoid, Huecoid, Barrancoid, and later the Arawak and Island-Carib) migrated from South America (Reid et al. 2014). In fact, analysis of mtDNA data recovered from the ancient skeletal remains found at Taíno sites in the Dominican Republic (n=24) and Guanahatabey sites in Cuba (n=15) has revealed mtDNA lineages among the skeletal samples that share strong affinity with modern South American Yanomami populations from the Amazon region (Hofman et al. 2018; Lalueza-Fox et al. 2001, 2003; Nieves-Colón 2014: 127).

Over the years, the presence of several communities in the circum-Caribbean has provided useful ethnographic information that is helping to unlock the narratives of the past (Reid et al. 2014). Central America also has an important place in Caribbean archaeology (Callaghan 1990, 1995, 2001; Hofman and Bright 2010a, 2010b), because territories in this region (especially Belize, the Yucatán Peninsula, and Nicaragua) have long had cultural connections to the Caribbean islands as a result of prehistoric migration and trade (Reid et al. 2014). Evidence suggests that Archaic groups from both South America and Central America migrated into the insular Caribbean, modifying landscapes, in some cases introducing new plant and animal taxa, and setting the stage for the development of subsequent farming communities. For a much more detailed discussion of the culture history, chronology, migration, and geographical distribution of cultural groups in the precolonial Caribbean and circum-Caribbean, readers are advised to review the following: Evans 2013; Hoopes 2017; Reid et al. 2014; Rostain 2014; Rouse 1992; Williams 2003; Wilson 2007 and Figure 0.1.

Inclusion of the Florida Keys in this volume represents a first, or rather a reunion since the 1970s, for pan-Caribbean studies. In many ways, its addition, in terms of the history of research is logically compelling, as some of the first American researchers worked in both regions (e.g., Bullen 1964, 1976; Bullen and Bullen 1970, 1972; Goggin and Rouse 1948; Rouse 1958). As the Florida Keys were part of the Calusa polity, news of these groups, if previously unknown, likely spread throughout the kingdom. It is likely that such connections also had a deeper history, as canoe travel between the Greater Antilles and the Florida Keys is certainly possible simply through drift (Callaghan 1999). Case studies from the Florida Keys area serve as a foil for Caribbean farmers, as our current understanding of these groups indicate that these people were marine fisher-gatherer-hunters who did not practice any form of agriculture (see Thompson et al. 2013). However, given that farming may be defined in a variety of ways, including strategies for long-term management of wild natural resources for subsistence purposes (Reid 2014; Siegel et al. Chapter 6 this volume; Ardren et al. Chapter 13 this volume), the early natives of the Florida Keys were also farmers as they appeared to be engaged in some form of plant manipulation.

Neolithic revolution versus Neolithic evolution

According to Price and Gebauer (1995) the transition to agriculture is perhaps the most remarkable event in the entire course of human prehistory. These sentiments are echoed by Weisdorf (2005: 561) who described the rise of Neolithic agriculture “as unquestionably one of the most important events in human cultural history.” Weisdorf (2005: 561) also asserted that “the transition to agriculture, which led to the rise of civilization and the procurement of material wealth beyond the wildest dreams of the Neolithic hunter and gatherer has been ascribed the title, the Neolithic Revolution”

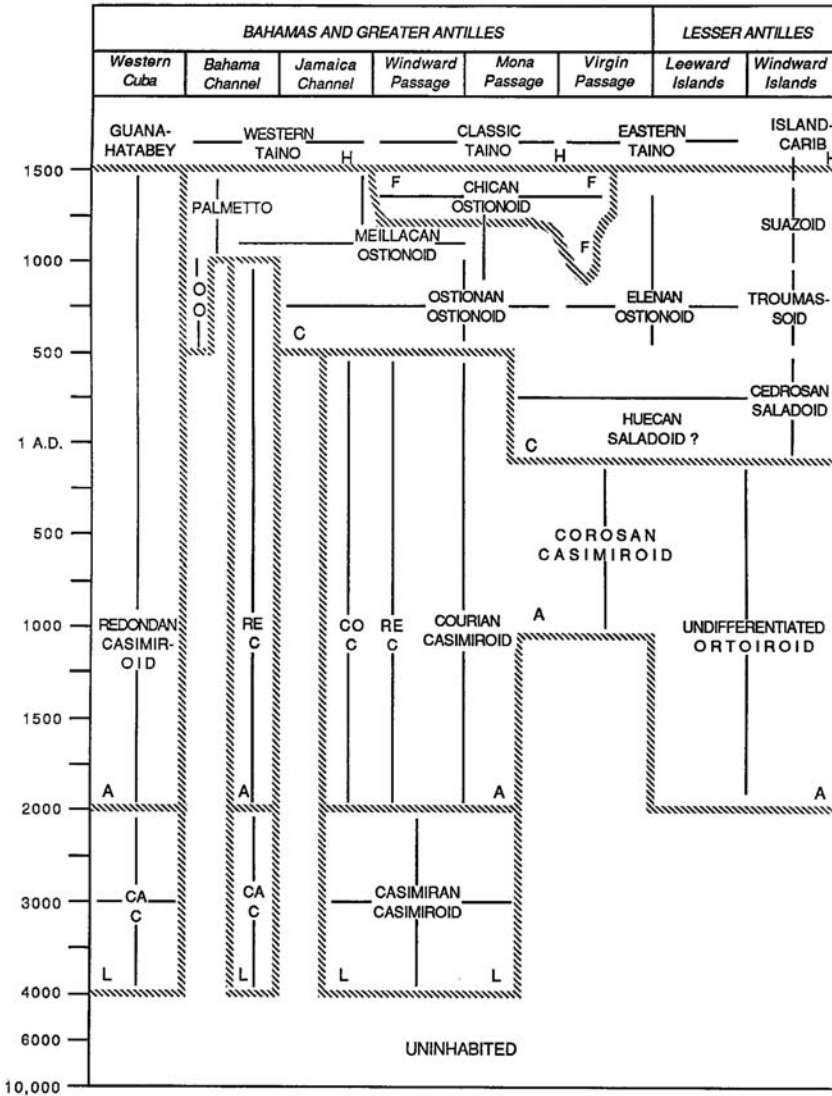


Figure 0.1 Benjamin Irving Rouse's time-space systematics showing the cultural evolution of indigenous groups in the Caribbean. Reprinted from Rouse (1992, adapted from fig. 8) by permission of Yale University Press.

(see also Childe 1936). For years, conventional thinking was that humans occupied our planet for several million years, but for almost all of that period they survived by various combinations of gathering, collecting, foraging, scavenging, fishing, and hunting (Barker 2006). With the rise in global

temperatures at the end of the Pleistocene about 12,000 years ago, the first clear evidence for farming activities began to emerge (Oliver 2001). This eventually led to a variety of agricultural systems based on cultivated plants and, in many areas, domesticated animals (Barker 2006). In other words, hunter-gatherers through force of external circumstances, be it climate change or population pressure (Binford 1968; Cohen 1977) inexorably became farmers. However, mounting archaeological evidence from the Caribbean and circum-Caribbean counters this foraging-farming paradigm.

Similar to the Midwestern United States (Keegan 2006: xi), what developed in the precolonial Neotropics was a scenario in which cultigens were gradually added to the diet (Pearsall 2009: 605) by a process called incidental domestication (Price and Gebauer 1995). This stage of domestication in the New World tropics includes perennials, such as fruit trees, agave, and cacti, supplemented in some places by annuals such as *Setaria*, squash, common bean, chili pepper, and *Zea mays* (Price and Gebauer 1995). There was apparently a long transition to agriculture, aptly described by Smith (2001) as a period of low-level food production. Clearly, the so-called Neolithic revolution was more evolutionary than revolutionary (Balter 2012; Cowan and Watson 1992). The concept of domestication is central to low-level food production, an evolutionary process with many stages between wild and fully domesticated plants (Pearsall 2009). The presence of domesticated plants is not the same as dependence on them. Rindos's (1984) model brought these perspectives together by distinguishing between domestication and agriculture and then linking these processes into a single model. Low-level food production is consistent with this co-evolutionary model, which predicts distinctive stages in the human-plant relationship, including a period in which domesticates are part of a system characterized by primary dependence on non-domesticated resources and high species diversity (Smith 2001). In their study of early horticulture and agriculture in the Neotropics, Piperno and Pearsall (1998) demonstrate many tropical lowland societies practiced food production for at least 5,000 years before the emergence of village life, and that by 7000 BP cultivated plots had been extended into the forest, with the concomitant felling of trees to admit sunlight to seed and tuber beds.

In the Caribbean and circum-Caribbean, domestication became an outgrowth of typical gatherer-forager practices (Harlan 1992; Pearsall 2009), a process that began during the Archaic Age in the region. Pearsall (2009) contended that co-evolution (Rindos 1984), human behavioral ecology (Kennett and Winterhalder 2006), and historical ecology (Balée and Erickson 2006; Fitzpatrick and Keegan 2007) are useful in reconciling these perspectives.

Defining farming

The foregoing brings into sharp perspective the often-complex issue of how *farming* should be defined. Farming, or agriculture, has been defined in a variety of ways: the practice of cultivating the land or raising stock; production that

relies essentially on the growth and nurturing of plants and animals, especially for food, usually with land as an important input; and the science or process of cultivating the soil to produce plants and animals that will be useful to humans in some way (Reid 2014). Horticulture, which derives from the Latin *hortus*, meaning a garden space, in contrast to an agricultural space, is usually defined as the science and art of growing fruit, flowers, ornamental plants, and vegetables in small gardens. Arboriculture is the cultivation and management of individual trees, shrubs, vines, and other perennial woody plants.

Ingold (1984: 5) has noted that anthropologists have the tendency to remove people from the category of foragers if they have any attributes of agriculture or pastoralism. There are really, however, three basic categories of human groups in terms of subsistence systems:

- 1) Those who subsist on uncultivated plants and wild fauna – foragers.
- 2) Those who have a mixed subsistence economy, based on a combination of domesticated and wild resources. These can be divided further into two subcategories: (2a) foragers who farm; and (2b) farmers who hunt.
- 3) Those who gain no sustenance from uncultivated plants and wild fauna – agriculturalists and pastoralists.

In general, anthropologists have tended to view the universe of human subsistence economies as a binary set: those in Categories 1 and 3 (Bogucki and Baker 1999). The root of the problem may be that colonization of Africa, the Americas, Australia, and the Pacific in the eighteenth and nineteenth centuries essentially “froze” many societies as either foragers or food producers, depending on their circumstances at the time of European contact. The point of this frozen moment was then assumed to be fixed on the unilinear scale of progress from hunting and gathering to farming and stock-herding (Reid 2009, 2014).

Thus, this really points towards the need for a more nuanced and complicated understanding of how we conceptualize farming, which is at its essence about the human control of the timing, amount, and spatial extent of subsistence resources. Keegan (2006: xi) argues that in the same way that foraging theory tends to focus on the capture of individual food items, the initial view of farming will do well to focus on the capture of individual plants. From this perspective, *farming* is *gathering* in a human managed context (Keegan 2006: xi). While much of the literature on farming has focused on the identification of domesticates, comparatively little attention is paid to how these practices co-emerged with increasingly sophisticated management and extraction technologies of so-called “wild” resources. From this perspective, farming is another dimension of the production process that is, for some groups, a compliment to the management of non-domesticated resources (see Thompson 2016).

As chapters in this book will demonstrate, the subsistence practices of the Caribbean and circum-Caribbean were far more complicated than the simple

typological models of subsistence. The evidence from this region suggests that there was a wide spectrum of subsistence economies. While some communities in the Caribbean and circum-Caribbean can properly be described as farmers, even though agriculture was in fact part of a larger network of other food-getting strategies such as collecting, fishing, and hunting (Reid 2014), others productively managed landscapes to produce subsistence surpluses that supported large populations (Thompson and Worth 2011). Siegel et al. (Chapter 2, this volume) argue that landscapes of opportunity (or cultural niches) were constructed by the earliest settlers generally as places where ethnobotanically useful taxa were selectively spared and nurtured. While this form of wildlife management does not necessarily represent cultivation, horticulture, or agriculture, these landscapes did set the stage for what eventually became places of incidental domestication or protocultivation (Siegel et al., Chapter 2, this volume). It is this diversity and the coupling of landscape management with farming that makes the Caribbean and circum-Caribbean an important case region for the study of the transition to agriculture.

Two key issues that are central to any volume on agriculture are (a) climate change and (b) human agency. Given that they provide a necessary backdrop for better understanding the emergence and development of farming communities in the Caribbean and circum-Caribbean, they are critically explored in this chapter.

Climate change and Caribbean/circum-Caribbean farming

Archaeologists studying human-environment relationships have become increasingly cognizant that climate change may have affected the course of culture history in many parts of the world. The influence that climate changes may have had on farming in the Caribbean during the middle to late Holocene is difficult to ascertain given both a paucity of paleoenvironmental data in the region and focused research on the subject by scholars. In addition, as Rivera-Collazo et al. (2015) note, answering this and related questions is further complicated by the fact that climate variations can trigger other environmental changes and that these can extend for decades or centuries, with humans responding to these at a much different temporal scale. Paleoclimatic data tend to be fairly coarse chronologically, extending over centuries or millennia. This complicates any attempt to establish connections between environmental changes and human behaviors.

Nonetheless, there has been a more concerted effort in recent years to collect different kinds of datasets to investigate and assess local and regional climate regimes (e.g., Siegel et al. 2015). This has led to an increased interest in how various climatic fluctuations may have affected prehistoric societies, such as rising sea levels, settlement patterns, and food security (Cooper 2013; Cooper and Peros 2010; Lane et al. 2014; Rivera-Collazo et al. 2015). However, few have explicitly addressed or found empirical evidence to demonstrate that these changes influenced food availability or agricultural production (see Keegan et al. 2008 for an exception regarding marine taxa).

Interpretation of the paleoclimatic record is often not straightforward; for example, separating climate-driven and anthropogenic agency in proxy records such as increases in charcoal in sediments is notoriously difficult (League and Horn 2000; see also Siegel et al. Chapter 2, this volume). As more data are produced, both by archaeological excavation and through paleoecological studies, it becomes more possible to distinguish regional patterns, such as pan-Caribbean climate changes, from local trends, more likely to be associated with anthropogenic effects (See Cartwright Chapter 9, this volume). The identification of regional trends, in turn, allows for a more nuanced understanding of cultural adaptation and resilience in the face of a changing environment. However, anthropogenic environmental change, even at the local level, could also pose significant challenges for the sustained habitability and carrying capacity of both islands (e.g., Keegan et al. 2008) and mainland regions (e.g., Turner and Sabloff 2012).

Perhaps the best study on the subject is how multi-decadal droughts between AD 750–1100 in Mesoamerica, termed the “Terminal Classic Drought” that was likely responsible for the decline of the Maya civilization, affected contemporaneous populations in the Caribbean. Lane et al. (2014), collating paleoenvironmental data from the Maya lowlands and the Cariaco Basin, suggest that climatic changes also affected the Caribbean, but in a much different way. Instead of creating similar xeric conditions, they actually “provided the impetus for more subtle cultural transitions that included intensified agricultural practices and, paradoxically, population increases in the Caribbean” (Lane et al. 2014: 96) that may have been the impetus for the rise of the Taíno. It is important to note here that proxy data from one locale may not be indicative of what is happening environmentally in another, and so differing climatic signatures observed across the Caribbean islands should be interpreted cautiously as to their influence on human populations (Fitzpatrick and Keegan 2007: 32).

Climate change has also been shown to be the driver of changing patterns of settlement and subsistence, including the development of landscape manipulations designed to regulate soil moisture levels for sustained cultivation (e.g., Cooper and Peros 2010). Climate change, especially periods of increased drought frequency and severity, also appears to have contributed to patterns of colonization and abandonment of mainland regions and islands alike (Beets et al. 2006; see also Dunning et al., Chapter 14, this volume). Human response to climate change and associated environmental challenges also extended into ritual and cultural symbolic realms as people attempted to exert influence over the environment in cosmological terms (see Roe et al. Chapter 7, this volume).

Human agency and farming

Unlike plants and non-human animals, actions performed by humans are purposeful and goal-oriented outside of the realm of pure ecological adaptation (Brumfiel 1992; Hodder et al. 1995; Meskell and Preucel 2004; Shanks

and Tilley 1987: 122–126; Yoffee and Sherratt 1993: 5). The early systems, cultural ecology, and optimal foraging approaches used the population as the unit of analysis, and when cultural change occurred it was viewed as an adaptive response to exogenous (usually environmental) factors (Bennett 1976; Hardesty 1977; Jochim 1981; Keene 1981; Meggers 1954; Sanders and Price 1968; Steward 1955).

Without engaging in a full-blown post-processual exercise, we do accept that individuals and groups of individuals function as teleological agents of change. Especially in the context of exploration and colonization of islands, these change-agents of the physical environment reflect on each new place vis-à-vis spatially or temporally distant and proximate experiences. The context of each new place investigated and settled by colonists includes not only the physical conditions of the new settlement and its environs but also the cumulative set of the colonists' previous experiences that are brought to bear as they engage in actions thought of as 'niche construction.' We argue that the agency of individuals and groups of individuals is not antithetical to the principles of evolutionary ecology; indeed, agency helps to contextualize shifting anthropogenic landscapes as products of deliberate, goal-directed actions. For instance, the earliest documented Archaic settlers of the Lesser Antilles approached the modification and management of landscapes differently across islands, reflecting variable distant and near-past experiences in new contexts as an ongoing process of landscape learning (Rockman 2003; Siegel et al. Chapter 2, this volume).

Goal-directed actions carried out by individuals or groups of individuals result in specific cultural outcomes (Brumfiel 1992: 558–560). At the scales of small groups of first colonists and later groups of new arrivals we see variable trajectories of landscape modifications and eventual food-producing strategies, island-by-island (Newsom and Wing 2004). By acknowledging that individuals and groups of individuals are capable of and actually do reflect and act on specific circumstances and ecosystem characteristics, we can reject views of cultural systems as equilibrium models "subject [only] to selection and adaptive change" (Brumfiel 1992: 559).

In order to provide an appropriate contextual framework for the miscellany of chapters in this volume, an overview is necessary of precolonial farming across the broad geographic coverage of the book chapters. First, it is essential that the *Archaic Age* be defined, given its critical importance to our understanding of the early development of farming in both the Caribbean and circum-Caribbean.

The Archaic Age

Archaic Age defined

As a term defining early hunting-gathering-collecting-foraging-fishing cultures without pottery and agriculture, the *Archaic* was first applied by William A.

Ritchie in northeastern North American archaeology (Ritchie 1932; Willey and Phillips 1958: 104–111). With ongoing research, Ritchie (1965: 31) found that pottery was in fact included in the repertoire of some Archaic assemblages and he observed that:

Far from uniform . . . the Archaic . . . displays a surprising variety in the details of its content, reflecting in part local ecological adaptations, and probably also the inherent dissimilarities of the several historically diverse traditions involved in its composition, as well as the varying interactions which took place between cultures within, and . . . outside, the area.

(Ritchie 1965: 32)

In their review, Willey and Phillips (1958: 107) added that specialized collecting and processing of wild foods were often associated with “early experimentation in plant domestication” and in some early Archaic cultures are found “the first evidences of New World agriculture.”

These early discussions of the Archaic were influential in the development of archaeology across the Americas. Consistent with the shifting views of the Archaic enumerated long ago by Ritchie and Willey and Phillips, the concept of the Archaic as a preceramic, pre-agricultural developmental stage has recently been questioned in some parts of the Caribbean. With the arrival of humans to Amazonia from at least 13000 BP, Trinidad approximately 8000 BP, the Lesser Antilles by about 5000 BP, and the Greater Antilles ca. 6000 BP to varying degrees landscapes were modified and eventually managed to suit the needs of the new explorers and colonists. As discussed by many contributors to the present volume, natural habitats were transformed into places of opportunity with reliable and predictable resources. Later colonists or descendants of the original settlers continued to modify and manage landscapes resulting in long trajectories of ecosystem engineering (Odling-Smee et al. 2013; Smith 2011).

For years, the Archaic Age was considered to be a developmental stage characterized by a marine-oriented subsistence followed by a terrestrial hunting-based economy (Goodwin 1978). Given mounting archaeological evidence to the contrary, a more appropriate definition for the Archaic Age in the Caribbean and the circum-Caribbean would be a period of marine-oriented subsistence followed by a terrestrial hunting-based economy, coupled with the transition from a highly mobile hunting and gathering life to a more settled agricultural lifestyle.

Caribbean Archaic farmers

Until recently, there was general agreement among Caribbean archaeologists that the Saladoid peoples were the first horticultural groups in the islands. Saladoid sites are found in abundance from Trinidad and Tobago to Puerto Rico.

Saladoid peoples had arrived in the Caribbean by 500 BC or earlier, bringing with them their South American farming background, including ceramic pots and griddles and a settled village-community life (large middens, plazas). However, the idea that the Saladoid peoples introduced pottery and agriculture for the first time to the islands is based on outdated models of cultural development and migration. Studies of preserved starch grains on grinding tools have demonstrated that virtually all of the plants that were supposedly introduced by the Saladoid peoples were already being cultivated by their Archaic predecessors (Newsom 1993; Pagán Jiménez 2011; Pagán Jiménez et al. 2015). This has given meat to the argument that in all likelihood there was never a ‘pre-agricultural’ period in the insular Caribbean (Pagán Jiménez 2011; Rodríguez Ramos et al. 2013).

Recent evidence indicates that pottery making and agriculture were already practiced in the islands by both the Archaic Casimiroid and Ortoiroid peoples for several thousand years before the Saladoid peoples arrived. New evidence, based on the analysis of starch grains recovered from grindstones, has provided the earliest maize (*Zea mays*) in the Caribbean and the earliest sweet potato (*Ipomoea batatas*), zamia (*Zamia* sp.), achira (*Canna* sp.), and chili pepper (*Capsicum*) in the Americas, found at the St. John Archaic site in southwestern Trinidad, which dates to 7790 years cal BP (Pagán Jiménez et al. 2015). Fruit trees in the sapodilla family (*Sapotaceae*) are represented by seeds and wood fragments from Twenty Hill on Antigua and by seed remains from Hichmans’ Shell Heap on Nevis. Other seeds from Archaic age sites derive from herbaceous or slightly woody plants. Seeds that are provisionally assigned to the genus *Siphonoglossa* sp. (Acanthaceae), cossie balsam, were recovered from Hichman’s Shell Heap (Newsom and Wing 2004; Reid 2009). Plants identified in Archaic deposits include zamia or coonite (*Zamia pumila*), cupey (*Clusea rosea*), wild avocado (*Persea americana*), yellow sapote (*Pouteria campechiana*), primrose (*Oenothera* sp.), mastic bully (*Mastichodendron foetidissimum*), and trianthema (*Trianthema portulacastrum*), and palms such as corozo have been found in the macrobotanical and microbotanical record of Puerto Rico (Pagán Jiménez et al. 2005). Recent analysis of starch grains in Archaic edge-ground cobbles from Puerto Ferro and Maruco in Puerto Rico show many similarities with cobbles from early sites in the Isthmo-Colombian area that had been used for processing tubers such as manioc (*Manihot esculenta*), sweet potatoes (*Ipomoea batatas*), and cocoyam (*Xanthosoma* sp.).

Circum-Caribbean Archaic farmers

Rather than interpreting Archaic pottery-making and horticulture in the Caribbean region as an isolated phenomenon, it should be viewed as part of a much larger emerging trend in the circum-Caribbean and New World tropics (Reid 2009, 2014). The Caribbean coast of Colombia is one of those areas where expressions of early pottery has been reported. Shell middens

such as Puerto Hormiga (Colombia) (5100–4500 BP or 3150–2550 BC) and the contemporaneous Monsú site (Colombia) seem to demonstrate the first attempts at village life in the region (Oyuela-Caycedo and Bonzani 2005; Ulloa Hung 2005). Their general characteristics suggest a transition from incipient agricultural practices and intensive gathering to a reliance on cultivated tubers such as manioc. This seems to be the case at other Colombian sites, such as Rotinet and Malambo, where the consumption of manioc in the form of cassava became habitual toward 2000 and 1200 BC, respectively. Sites studied in the region of Carupano in Venezuela provide significant examples of the development reached by foraging groups from this region of South America. These sites consist of large shell middens that provide evidence of surface ceramics and a mixed economy. The foragers of this area of Venezuela settled coastal areas near mangroves and lagoons in the Gulf of Paria and the Gulf of Cariaco. In Guyana, on the other hand, studies of Late Archaic groups associated with shell middens (such as Hosororo Creek, which has been dated to 3975 ± 45 BP (or 2025 BC) document how communities with a basic gathering economy developed undecorated pottery with very simple forms.

In Central America, some shell middens such as Monagrillo in the Gulf of Panama (4500–3200 BP, or 2550–1250 BC) have evidence of a certain ceramic industry related to the use and exploitation of nearby resources in the mangrove swamp. The pottery at this site supports the impression that this location was home to an important phase in the dispersion and exchange of ceramic traditions in the Americas. In general, shell middens with ceramics from Colombia, the coast of Venezuela, Guyana, and Panama reflect a phase of growth and intensification of foraging lifeways in the continental or riverine Caribbean that was characterized by experimentation with some horticultural practices and the manufacturing of wood-working instruments and tools (Reid 2014; Ulloa Hung 2005; Williams 2003).

The archaeological and paleoecological detection of the onset of agriculture in Panama and elsewhere in Central America was long hindered by the relative “invisibility” of many cultigens, especially root crops and insect-pollinated fruit trees that typically were not apparent in pollen-bearing sediment records which were for many years the principal proxy for ancient vegetation. Over the past 20 years, improved phytolith analysis capabilities have documented food-producing systems in Panama that evolved slowly between 9000 and 4000 BP, including arrowroot (*Maranta arundinacea*) and achira (*Canna edulis*) as well as squashes and gourds, in addition to maize, which was already known from pollen records to have been in Panama by 7000 BP (Piperno 2007). The more recent application of starch grain analysis to Archaic tools has further identified beans, manioc, and yams in Panama by 4000 BP.

In Mesoamerica, partial transition from foraging to agriculture also typically occurred well before the adoption of ceramic technology. In coastal areas, crop production often appeared in combination with the exploitation of marine, estuarine, or riverine resources in sedentary settlements as early as 7300 BP

at San Andres, Tabasco on the Gulf of Mexico (Pohl et al. 2007) and 6500 BP on the Pacific Coast of southern Mexico and Guatemala (Kennett et al. 2010). Inland, a growing number of cave and rock shelter sites record agricultural production long before ceramics appear, including the oldest known record of maize production in the dry tropical forest of the Rio Balsas drainage in Guerrero, Mexico (Piperno et al. 2009; Ranere et al. 2009). In many inland cave sites in Mesoamerica other domesticated crops such as various squashes (*Cucurbita* spp.) and beans (*Phaseolus vulgaris*) appear well before maize (McClung de Tapia 1992). Across Mesoamerica, the triad of crops (maize, beans, and squash) that came to characterize the subsistence economy of the region was well established by 4000 BP, still within the time frame of the Archaic.

Along the southern coasts of the United States, the shift to agriculture was more protracted, and in the southern parts of Florida farming was never adopted (Thompson et al. 2013). However, as with the other regions discussed, the transition to village life, the invention of pottery, and the exploitation of estuarine resources occurred relatively early during the Late Archaic period (ca. 5000 to 3000 BP). Large circular shell midden sites, or shell rings, along the Gulf Coast of Florida and the Atlantic Coast of Florida, Georgia, and South Carolina is the primary site type that evidences this transition. Numerous studies indicate that these sites were occupied year-round and represent early village societies in the region (Russo 1998; Thompson 2007, 2010; Thompson and Andrus 2011). These sites have some of the earliest ceramics in the United States, and in some cases, may represent early evidence of the mounding of shell.

Most interesting is that in at least one region where shell ring sites occur (NE Florida) the groups encountered by Europeans in the sixteenth century spoke a language isolate, Timucua, which is argued by Granberry (1993: 41) to have originated in northwestern Amazonia with a dispersal route through the Caribbean. Although, Granberry's ideas have not been borne out via archaeological testing and he certainly had his critics, at least on a superficial level the similarities between the shell ring sites in Colombia with early pottery (i.e., Puerto Hormiga [Reichel-Dolmatoff 1965]) and those in the American Southeast have not been lost on researchers over the years (Ford 1966; Sears 1977). However, to date independent invention over diffusion models is the preferred explanation for such variability in early pottery adoption (Hoopes 1994: 42–43).

Farming in the Ceramic Age of the Caribbean and circum-Caribbean

Ceramic Age Caribbean

The transition to the so-called Ceramic Age in the Caribbean islands was a gradual process, starting with plant management and the manufacture of

clay pots by Archaic Age communities to a fully developed horticultural and ceramic production between 800 and 200 BC. Besides the recent discovery of the early presence of plant cultivation in Archaic Age sites all over the Caribbean, the early appearance of pottery is particularly well documented in the Greater Antilles (Cuba, Dominican Republic, Puerto Rico) (Rodríguez Ramos et al. 2008; Ulloa Hung and Valcárcel Rojas 2013), but has been recently also found in Archaic Age context in the Leeward Antilles (Curaçao) (Hoogland and Hofman 2015). In the northeastern Caribbean (between Puerto Rico and Guadeloupe) the earliest Ceramic Age sites (Huecoid and Saladoid series) appear contemporaneously with sites with a typical Archaic Age toolkit until about AD 100 (Bonnissent 2013; Hofman et al. 2006, 2014b).

Early Ceramic Age societies have been looked at in the past as egalitarian, tribal, Big man, local groups headed by a shaman-leader, or complex tribes with achieved leadership (Boomert 2000; Hofman et al. 2004; Petersen 1996; Siegel 1996). Settlements have habitation areas surrounded by dense refuse middens and the deceased were buried either in the habitation area or in a central plaza (Hoogland and Hofman 2013; Siegel 1992). Subsistence practices included the cultivation of ground provisions, fishing, hunting, and collecting, and therefore a variety of habitats in the interior of the islands as well as near rivers, beaches, mangrove areas, and reefs were exploited. Starch grains on clay griddles and *Codakia* shell scrapers point to the cultivation and the preparation of a variety of root crops during the entire Ceramic Age (Pagán Jiménez 2011; Rodríguez Suarez and Pagán Jiménez 2008).

The Caribbean islands have always been vulnerable to natural disasters and were severely affected by periods of drought between AD 700 to 900 (Beets et al. 2006; Hofman and Hoogland 2015a; Malaizé et al. 2011), concurrently with the Maya collapse in the Yucatán area. Significant shifts in settlement locations, settlement density, and exploitation strategies were the result (Bradford 2001; Bright 2011; Haviser 1997; Hofman et al. 2004). Micro-regional interaction spheres developed between the northern Lesser Antilles, the Virgin Islands, Puerto Rico, and the Greater Antilles, and between the Windward Islands, Trinidad and the eastern portion of the South American mainland (Boomert 2000; Hofman 2013).

Larger local socio-political units were formed based on kin and trade relationships and socio-political restructuring (Crock 2000; Haviser 1991; Hofman 2013; Hofman and Hoogland 2011; Hofman et al. 2007, 2008, 2010; Hoogland 1996; Rodríguez Ramos 2010). Villages evidence long time occupation through the accumulation of Saladoid, Troumassoid, and Suazoid cultural remains (Bradford 2001; Bright 2011; Hofman et al. 2001). Many habitats and eco-niches were exploited suggesting that activities were evenly spread across the landscape and less centralized in a few large settlements as was the case during the early Ceramic Age (de Waal 2006; Hofman et al. 2004; Hofman and Hoogland 2011). The heavily marine-oriented diet was supplemented with rice rats, agoutis, peccaries, guinea pigs, and

armadillos (Boomert 2000; Fitzpatrick et al. 2009; Giovas et al. 2012; Grouard 2001). A wide variety of plant foods such as maize, root crops (manioc, sweet potatoes, yams, zamia), beans, and fruits were cultivated and processed (Hoogland et al. 2015; Mickleburgh and Pagán Jiménez 2012; Newsom and Wing 2004; Pagán Jiménez 2011). On Bonaire, Curaçao, and Aruba, the first Dabajuroid settlements were established between AD 800 and 1000, with links to central and west Venezuela. The processing and preparation of manioc and maize have been deduced from the presence of microflakes and metates in Dabajuroid sites (Haviser 1987).

During the Elenan Ostionoid period, the number of sites in the Virgin Island group and Puerto Rico proliferated, and populations exploited a variety of resource habitats (Bates 2014: 350). Throughout the Saladoid and Elenan Ostionoid periods, the inhabitants of the Virgin Islands primarily exploited the coastal plain areas of the islands. The coastal plain would have provided the most appropriate environment for horticulture, particularly cassava cultivation, and easy access to the inshore and reef marine species that they were exploiting for subsistence (Bates 2014: 350).

On Aruba settlements with round and oval structures (i.e., Tanki Flip) are located near one or more gullies, which were used as natural irrigation channels and facilitated travel and communication across the island (Versteeg and Rostain 1997). At the time of European encounters, the cacicazgos of the Caquetío were disrupted and a large portion of the population from the ABC islands was transported and forced to work in the goldmines in Hispaniola (Dijkhoff and Linville 2004). In the Greater Antilles, civic-ceremonial plazas were constructed from around AD 600. On Puerto Rico these plazas were surrounded by stones with petroglyphs (e.g., Tibes, Caguana, Jácana) (Curet 2005; Espenshade 2014; Oliver 1998; Siegel 2010), and in central and northern Hispaniola by earthen walls (e.g., Constanza, bel El Cacique, El Carril) (Hatt 1932; Sonnemann et al. 2016; Veloz Maggiolo 1972). The so-called Taíno culture (Chicoid series) reflects unity and diversity of the peoples who populated the northern Caribbean at the time of contact (Curet 1992; Ulloa Hung 2014; Wilson 2007). Cacicazgos with powerful caciques dominated the landscapes of Hispaniola, Puerto Rico, and Cuba with numerous hamlets and villages under their control (Torres 2013). European chroniclers documented five such cacicazgos in Hispaniola. In Cuba, 20 *provincias indias* were mentioned that in some cases are structures similar to cacicazgos but with less power, less social differentiation, and subordination between the caciques (Valcárcel Rojas 2016: 49–52). Chiefs and their families can claim the best farmland or fishing places, as well as more food than the families of commoners. In chiefdoms, control over production and exchange of subsistence and wealth creates the basis for political power (Reid 2009). In the Caribbean, caciques presided over the village in which they lived. They organized daily activities and were responsible for the storage of surplus commodities, which they kept in buildings constructed for this purpose and redistributed among the villagers as needed (Rouse 1992).

In the northwestern Dominican Republic villages consisted of a number of houses surrounded by earth works and multi-functional mounds or montículos sometimes two meters in height reflecting the domestic and ritual activities of each household (e.g., El Flaco) (Hofman and Hoogland 2015b; Hofman et al. 2018). Such mounds were previously interpreted as agricultural residuaries (e.g., El Carril) (Veloz Maggiolo 1972). Plant fertilization was thought to have taken place in the upper layers of the mounds. The humidity would have increased in these layers because of the pavement layers that would have prevented the water from draining through rapidly. Other than serving agricultural purposes, the mounds also presented garbage deposits. All types of organic materials would have increased the fertilizing potential of these mounds. It was hypothesized that next to organic materials used as fertilizers also inorganic matter was deposited in the *conuco* as votive offerings (Veloz Maggiolo 1972). Other sites in the region present small circular *montones* (e.g., Playa Grande), which were purposely raised from soil for the planting of root crops (Lopez Belando 2012). Plots of land with sometimes hundreds of *montones* are also described by the first European chroniclers.

In a first region wide study, starch grains from human dental calculus from the pre-Columbian insular Caribbean (dating to ca. 350 BC to AD 1600) were used to identify important plant foods in the diet and to assess potential dietary differences related to age or sex (Mickleburgh and Pagán Jiménez 2012). Samples were derived from El Chorro de Malta (Cuba); Juan Dolio, El Cabo, and Punta Macao (Dominican Republic); Maisabel (Puerto Rico); Tutu (Virgin Islands); Kelbey's Ridge (Saba); Anse à la Gourde (Guadeloupe); Point de Caille (St. Lucia); Escape (St. Vincent); Manzanilla (Trinidad); and Malmok, Tanki Flip, and Canashito (Aruba). The results indicate that maize was more commonly consumed in the insular Caribbean than originally thought. The variety in other plants identified (mostly tuberous root crops) shows that the pre-Columbian inhabitants of the region followed a broad spectrum, but locally available diet in which a variety of root crops functioned as staple crops, including marunguey (*Zamia* sp.) and sweet potatoes (*Ipomoea batatas*) (Mickleburgh and Pagán Jiménez 2012). There were no indications for the traditionally assumed heavy reliance on manioc (*Manihot esculenta*) cultivation in the region, which led Mickleburgh and Pagán Jiménez (2012) to speculate that the frequent mention of manioc in the literature over the years may have been more of a function of bias in the Spanish ethnohistorical records than archaeological reality.

Ethnohistoric evidence for agricultural practices in the Caribbean

In addition to archaeological and paleoenvironmental evidence for landscape modification and management, plant manipulation and selection, horticulture, and farming, ethnohistoric sources provide insights into indigenous agricultural practices. The contact-period cultures of the West Indies represent the outcome of thousands of years of interactions, trade-and-exchange initiatives,

plant and animal introductions, and experiments in plant and animal domestication. Insights gained from ethnographic or ethnohistoric observations of subsistence practices may be valuable in addressing precolonial practices. However, it is important to critically assess the social, political, and economic context of the ethnographic and ethnohistoric sources when using that information to assist in interpreting the archaeological deep past (Wylie 1985). In the absence of some convincing justification or line of evidence, it is inappropriate to push ethnographic or ethnohistoric data into the past to interpret or explain aspects of the archaeological record (Wobst 1978).

Many of the primary and secondary sources addressing contact-period indigenous cultures in the Caribbean distinguish between Taíno and Island Carib lifeways. There has been considerable debate as to the reality of this distinction and some have argued that the 'Island Carib' designation was an artifact of European politically motivated agendas (Allaire 1977, 1980; Davis and Goodwin 1990; Sued Badillo 1978). Addressing the distinction between Taíno and Island Carib cultures is beyond the scope of this book. However, we will summarize agricultural practices that can be gleaned from the sources for the geographic distribution of the Taíno (Greater Antilles) and so-called Island Caribs (Lesser Antilles from Grenada to Guadeloupe).

In the Greater Antilles, the Spanish documented a series of stages in preparing horticultural plots. In wooded areas, trees were removed and burned. The ground was broken using a dibble, after which small conical-shaped mounds (*montones*) were formed about 50 cm tall and 3 to 4 m in diameter. *Montones* provided aerated, well-drained soils for cultigens. Intercropping was practiced with an emphasis on a variety of root crops, including yams, sweet potatoes (batata, age, *Ipomoea batatas*), bitter and sweet manioc (yuca, *Manihot esculenta*), yautía (*Xanthosoma* sp.), arrowroot (*Maranta allouia*), yampee (*Dioscorea trifida*), lleren (*Calathea* sp.), canna (*Canna* sp.), and peanut (*maní*). Seed crops included maize (*Zea mays*), beans (*Phaseolus* sp.), and squash (*Cucurbita* sp.). Vines (lianas) were also planted to reduce erosion from heavy rainfall. A discrete cluster of *montones* was called a *conuco* (horticultural plot) (Arrom 2000; Dunn and Kelley 1989; Joyce 1916; Las Casas 1951; Martyr D'Anghera 1912; Moscoso 2001; Oviedo 1950; Sauer 1966). In the humid tropical regions of the Greater Antilles, consistent rainfall was an adequate source of water for the crops. Irrigation agriculture was documented in the xeric region of southwestern Hispaniola (Xaragua) and parts of Cuba with an ordered system of canals and ditches diverting water from the main river channels to *conuco* fields (Joyce 1916: 211–214; Martyr D'Anghera 1912: 387–388; Robiou Lamarche 2005: 121–123; Sauer 1966: 51–58).

When the prehistoric environments of the Bahamas archipelago and the Greater Antilles are compared from the perspective of the Taíno colonists, the Bahamas appear as an attractive alternative to subsistence intensification on Hispaniola (Keegan 1992: 46–47). Root crops provide high yields on relatively poor soils, and the more pronounced dry season of the southern

Bahamas may have promoted even higher yields of manioc per hectare than those obtained along the north coast of Hispaniola (Keegan 1992: 47). Humic-enriched sandy soils provide the best medium for planting root crops because they promote efficient root growth and because soil preparation and weeding is less difficult than on other soils (Keegan 1992: 47).

Cultivation practices in the Lesser Antilles appear to have been similar to those of the Greater Antilles (Labat 1984; Martyr D'Anghera 1912; Rouse 1948; Sauer 1966; Sheldon 1820). In some of the sources it was suggested that kitchen or home gardens (*huertas*) were more prevalent in the Lesser Antilles than the Greater Antilles, although this observation may have been simply a product of how different recorders defined a “kitchen garden” (Las Casas 1951; Martyr D'Anghera 1912; Oviedo 1950; Sauer 1966). It was documented too that pineapples were cultivated in the Lesser Antillean *huertas*, particularly on Guadeloupe (Labat 1984: 248–251; Martyr D'Anghera 1912: 390; Sauer 1966: 57). Island Carib (Kalinago) presence in the islands occurs until the early colonial period with strong relationships to both the Greater Antilles and the Guianas (Koriabo pottery) (Boomert 1987; Hofman et al. 2008). This is reflected in the so-called Cayo pottery found between Grenada and Guadeloupe (Bright 2011; Hofman 2013). Kalinago settlements were often located along the eastern shore, facing the Atlantic Ocean, and in proximity to rivers. Kitchen gardens were located near houses, and larger horticultural gardens were located in the mountains where many isolated stone tools have been found (Hofman and Hoogland 2012; Hofman and Hoogland 2015a). The indigenous Caribbean at the time of European encounters represented a mosaic of cultures with a myriad of interactions across the Caribbean Sea (Hofman et al. 2014a; Wilson 2007). This pristine and multi-cultural social landscape was transformed forever after 1492.

Circum-Caribbean Ceramic Age

By 1000 BC, much of Mesoamerica was becoming an ever-changing patchwork of forest and fields (Dunning and Beach 2010). As noted earlier, the transition from hunting and gathering/fishing and gathering subsistence systems was typically a gradual process. Mixed economies that included hunting/fishing, foraging, and cultivation may have persisted into the Formative (Preclassic), possibly even extending into the early years of Olmec Civilization along the Gulf Coast of Mexico (Killion 2013).

Feinman (2001) has compared Early/Middle Formative (1000–500 BC) Mesoamerican societies to “Regional Classic” (AD 450–900) societies in central Panama in terms of socioeconomic integration models. Although sedentism and agriculture had been present in both regions for millennia, the development of social complexity took different trajectories. Mesoamerican groups generally developed with considerably more emphasis on *corporate strategy*, often manifest in investment in ritual spaces such as plazas and public platforms; whereas the Panamanian groups developed a *network*

strategy focused on accumulating personal wealth – though this accumulation may have been associated as much with cultural offices as with specific individuals. The Barriles site of the Gran Chiriquí is among the larger centers documented in Panama, likely having a resident population of between 500 and 1,000, little public architecture, but social stratification manifest in elaborate elite burials, iconography, and wealth accumulation in gold and jade artifacts (Hoopes 2005; Quilter 2003). The political-economic mechanisms of the Panamanian network model did not spawn urbanism or high population densities, and intensive agriculture was notably absent (Cook and Ranere 1992). In contrast, while the emergence of social stratification within Costa Rica's Formative (300 BC to AD 300) initially produced very modest evidence of political-economic centralization, after AD 300 the size of polities began to increase markedly along with trade networks, craft specialization, and investment in public architecture (Quilter 2003; Vázquez Leiva and Chapdelaine 2008). The growth of complexity was also manifest in an intensified agricultural system that included maize, cotton, palms, and numerous fruit-bearing trees.

Classic and Postclassic period Mesoamerica (ca. AD 200–1500) is difficult to generalize in terms of either type of political, economic, or social organization or in terms of agricultural strategy because the region was tremendously environmentally and culturally diverse (Dunning et al. 2015). Suffice it to say, agricultural strategies were successfully adapted to environments ranging from highland deserts to tropical lowland wetlands, and population concentrations that supported urbanization occurred in virtually every niche at one time or another – although population and the success of associated societies waxed and waned considerably through time.

Research in the Maya Lowlands has shown that there is no linear relationship between the degree of political-economic centralization and agricultural intensification. While some of the greatest manifestations of intensification were associated with complex, centralized urban entities (e.g., the city of Caracol, Belize; see Chase and Chase 1998), other areas exhibit high levels of agricultural intensification, but very low levels of centralization (e.g., the rural landscape of the Rio Bec region of Mexico; see Lemonnier and Vannière 2013). The relationship between population density and environmental impact is similarly non-linear in Mesoamerica. For example, at Lake Patzcuaro in the central Mexican Highlands, Fisher (2005) found that maximum soil erosion occurred during initial Preclassic urbanization and land clearance and again in the early Colonial era when rapid depopulation occurred and Classic and Postclassic conservation terrace systems were abandoned; during the Postclassic population zenith, the landscape was stabilized by intensive maintenance of conservation infrastructure. Similarly, in the Maya Lowlands the greatest amount of land degradation often occurred in the Preclassic when forest removal was not offset by terracing or other forms of landscape stabilization, whereas further population growth in the Classic period often induced the introduction of landscape conservation measures (Dunning and Beach 2010).

Nevertheless, rising population levels in the Classic period ultimately produced significant environmental stress and increased the vulnerability of Maya communities to perturbations such as drought and hurricanes as well as social pressures such as inter-polity warfare (Dunning et al. 2012).

Book chapters

Many of the foregoing broad trajectories in both the Caribbean and circum-Caribbean are captured to varying degrees by the 17 chapters in this volume. Chapter 1 by Scott M. Fitzpatrick utilizes a historical ecology approach to examine the major long-term trends currently observed in pre-Columbian archaeological, archaeobotanical, and paleoenvironmental records. His chapter demonstrates the utility of using multiple datasets to observe how humans were both influenced by and transformed their ecologically fragile environments. Chapter 2, authored by Peter E. Siegel, John G. Jones, Deborah M. Pearsall, Nicholas P. Dunning, Pat Farrell, Neil A. Duncan, Jason H. Curtis, and Sushant K. Singh addresses the first humanization of early to mid-Holocene landscapes in the Lesser Antilles through a program of environmental coring. On the basis of plant microfossils (pollen, phytoliths, charcoal particulates), characterization of sediments, watershed analysis and radiocarbon dates, their chapter offers a refinement of our understanding of early colonization patterns and survival strategies, heretofore only available from archaeological excavations.

Corinne L. Hofman, Reniel Rodríguez Ramos and Jaime R. Pagán Jiménez (Chapter 3) challenge the normative view of *Neolithization*, arguing instead for a more dynamic process resulting from complex fusions and mixtures of endogenous and exogenous traditions that converged and were negotiated among myriad groups of peoples of the so-called Archaic and Ceramic Ages. Written by David Gray Smith, Yadira Chinique de Armas, Roberto Rodríguez Suárez, William M. Buhay, Ivan Roksandic, Matthew C. Peros and Mirjana Roksandic, Chapter 4 places the spotlight on common bean (*Phaseolus vulgaris*) starch grains from human dental calculus recovered from burials at the mortuary site of Canímar Abajo (Cuba). They argue that this recently recovered evidence from mortuary sites in northwestern Cuba indicates that Late Archaic subsistence practices on the island were much more complex than previously thought. Andrzej T. Antczak, Jay B. Haviser, Menno L. P. Hoogland, Arie Boomert, Raymundo A. C. F. Dijkhoff, Harold J. Kelly, Ma. Magdalena Antczak, and Corinne L. Hofman (Chapter 5) discuss current knowledge of the causes, dynamics, and timing of the processes involved in the transition from Archaic Age gatherer-fisher-hunter economies to horticulture-based farming in the Southern Caribbean. They present geo-environmental background information as well as offer a brief overview of the earliest signatures of human presence in this study region.

Chapter 6 by Michelle J. LeFebvre and Susan D. deFrance discusses the topic of domestic and managed wild animals among late Ceramic Age

(AD 500–European Contact) farmers-fishers-hunters of the Caribbean islands. The chapter focuses on domestic guinea pig (*Cavia porcellus*) and hutia species (Family: Capromyidae) as case studies to discuss how archaeologists might better recognize and study intentional human manipulation of animals in the West Indies. Contextualized within broader archaeological perspectives of domestic animals among farmers, the authors suggest that more attention is needed on the commensal and symbiotic relationships that Ceramic Age populations had with both guinea pigs and hutias. In Chapter 7, Peter G. Roe, Michele H. Hayward and Michael A. Cinquino suggest that the region's petroglyphs, pictographs, and portable carved figures reflect a magio-religious attempt at fertility controls – albeit rather tenuously in the Archaic transitioning to a general expression in the Saladoid to certain specific images in the Ostionoid. Basil A. Reid, Frank R. Thomas and Scott M. Fitzpatrick (Chapter 8) provide both a review and comparative study of pre-colonial farming in the Caribbean vis-à-vis the Pacific. Their chapter explores major types, geographical ranges, and chronologies of cultivars and domesticated animals, as well as the socio-political systems characteristic of both the Caribbean and Pacific farming communities.

Chapter 9 by Caroline R. Cartwright highlights the advantages of scanning electron microscopy in enhancing wood and charcoal identification together with other best practice principles and procedures for reconstructing the woody resources of early farmers in the Caribbean. Focusing exclusively on the island of Puerto Rico, Isabel C. Rivera-Collazo and Lara M. Sánchez-Morales (Chapter 10) consider how human activities modified the land within two archaeological sites of different periods: Angostura and Salto Arriba. Using geoarchaeological analyses, their chapter reveals that Archaic settlement was more intense than expected, becoming an important pedogenic agent, while later agroceramist occupation seems to have been more extensive but less intense, and included planned investment of time and effort to enhance land productivity. William J. Pestle and Reniel Rodríguez Ramos (Chapter 11) critically explore stable isotopes preserved in human tissues for prehistoric Puerto Rico. They contend that while this technique holds considerable promise for the characterization of ancient human subsistence, a variety of local factors, including poor preservation and the complexity of available foodwebs, can combine to make even relatively coarse dietary determinations (e.g., foraging versus fishing versus farming) difficult. Chapter 12 (by Hayley L. Mickleburgh and Jason E. Laffoon) assesses long-term subsistence patterns on prehistoric Aruba on the basis of dental anthropological and stable isotope analyses. Their study does not reveal any distinct differences between individuals from the Archaic Age sites of Canashito and Malmok and the Ceramic Age (Dabajuroid) sites of Santa Cruz, Savaneta, and Tanki Flip.

Utilizing new data from two sites of extensive faunal and marine shell artifacts and ecofacts from two sites in the Florida Keys, Traci Ardren, Victor D. Thompson, Scott M. Fitzpatrick, Joseph Stevenson, and Roger L.

Sierra (Chapter 13) explore the nature of Keys subsistence practices in relation to better documented circum-Caribbean and Calusa evidence. The authors suggest their data best fit within a model of social complexity based on persistent foraging that included aspects of environmental management and soil modification. Nicholas P. Dunning, Timothy Beach, Elizabeth Graham, David Lentz, and Sheryl Luzzadder-Beach (Chapter 14) discuss the rapidly growing body of data documenting the importance of several root crops among the ancient Maya beginning in the Preclassic period. These crops included manioc (*Manihot esculenta* Crantz.), malanga (*Xanthosoma sagittifolium* (L.) Schott), achira (*Canna edulis*), and sweet potato (*Ipomoea batatas*). Over time, the Lowland Maya developed a complex, spatially varied agricultural system capable of supporting large urban populations. Robert P. Kruger (Chapter 15) discusses the long and complex manner in which maize (*Zea mays*) came to be adopted as the primary staple crop of Mesoamerica. From its apparent domestication in the Rio Balsas Valley of Mexico in the sixth millennium BC, maize was dispersed throughout much of Central and South America within 2,000 years.

In Chapter 16, Stéphen Rostain presents an overview of the major agricultural developments in the Guianas. Rostain is of the view that these first farmers developed variations of shifting cultivation, such as short-fallowing or agroforestry. The chapter includes a discussion of a particular type of *terra firme* farming in various parts of Amazonia, which involved the production of fertile black anthropogenic soils called *terra preta*. Another major theme in this chapter is the development of raised fields. The volume rounds out with Chapter 17, written by Martijn M. van den Bel, Sebastiaan Knippenberg and Jaime R. Pagán Jiménez. Their chapter details recent excavations at two archaeological sites in French Guiana (Eva 2 and Saint-Louis), which yielded evidence of Late Archaic and Early Ceramic Age occupations that are comparable to other coastal sites in South America. According to van den Bel et al., starch grain analysis showed that maize, sweet potatoes, arrowroot, and jack beans, were consumed among the Early Ceramic Age populations of French Guiana who made use of polished tools, oven or cooking pits, and large and spherical cooking pots in order to prepare food during the second half of the third millennium BC. The results of these large scale excavations have added new data to this almost unknown but innovative episode in northern Amazonia, i.e., the shift from the Preceramic to the Ceramic Age or Formative Period.

Conclusion

One of the takeaway points in many of the Caribbean chapters is that dichotomizing survival strategies between agricultural versus non-agricultural lifeways creates a caricature of real-world human behavior. The complexities in food-getting strategies were also highlighted in some now-classic treatments of the topic: Foragers *and* Farmers (Gregg 1988, emphasis added) and the

worldwide survey of Foraging *and* Farming (Harris and Hillman 1989, emphasis added). As Cowan and Watson also observed long ago, “crop plants were gradually added to a foraging-based economy . . . that domestication is a product of cumulative changes in a plant species [and that] it is probably not possible to discover ‘when’ plants were first domesticated” (Cowan and Watson 1992: 207, 209). Owing to the long-term gradual and cumulative process of domestication, Cowan and Watson (1992: 210) concluded “There is, in fact, no Neolithic ‘revolution’ [and that] . . . the history of agriculture . . . is one of gradual change, not revolution.” These ideas of long-term, gradual shifts in subsistence economies, whereby domestication occurred over centuries if not millennia, are consistent with Hofman et al.’s (Chapter 3) discussion of the *Neolithization* process spanning the Archaic and Ceramic Ages in the Caribbean.

Given its multi-disciplinary approaches, this volume should be of immense value to both researchers and students of Caribbean archaeology, biogeography, ethnobotany, zooarchaeology, historical ecology, agriculture, environmental studies, history, and other related fields. This volume contributes to our understanding of the current state of research in the Caribbean and circum-Caribbean, and provides valuable insight into the complexities of ancient daily life in the region. It also expands the Caribbean world by including research from places that, until recently, have been regarded as outside the traditional sphere, namely the Florida Keys.

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Part I

Caribbean farmers from a regional perspective



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1 Comparative perspectives on pre-Columbian farming in the Caribbean as seen through the lens of historical ecology

Scott M. Fitzpatrick

Introduction

The “Columbian Exchange” that Alfred Crosby (1972) so eloquently explored in his famous treatise decades ago highlighted the diversity of biota that was transferred between the Old and New Worlds and the impact these had on human populations and the environment. While there is no question that the movement of plants, animals, pathogens, and various microbiomes dramatically altered societies on a global scale after 1492, these were in fact preceded by earlier imports that began centuries or even millennia earlier. As archaeological, paleoethnobotanical, and paleoecological research in the Caribbean has shown, Amerindian groups who began to settle the Antilles sometime after ca. 8000 years ago became increasingly active through time in bringing with them to the islands numerous cultivars and animal species (Newsom and Wing 2004; Giovas et al. 2012; Pagán Jiménez et al. 2015; Stahl 2009). As food production became more widespread and important during the Ceramic Age post-2500 BP, populations grew (see Curet 2005) and by ca. 1400 BP, most of the islands in the Antilles and Bahamian archipelago were occupied (Fitzpatrick 2015). What were these biota and how did humans affect these pristine islands over the course of occupation? Were there any resulting environmental transformations or impacts that are discernible in the paleoenvironmental and/or archaeological record?

To help answer these questions, historical ecology—essentially analogous to ‘human ecodynamics’—can serve as a mechanism or lens for viewing long-term changes to environments across space and time and the resulting modifications that may have occurred as a result of human intervention (Kirch 2007; McGlade 1995). Islands are particularly amenable to this kind of approach given the scale of their biological evolution that occurred over hundreds of thousands or even millions of years in the absence of humans. This led Vitousek (2002) to label islands as ideal “model systems” (see also Kirch 2007)—landmasses surrounded by an aquatic perimeter that was not easily surpassable by humans until relatively recently, but whose ecologies were particularly susceptible to the effects of what Balée (1998) termed *Homo devastans*—the ultimate landscape modifier.

In this chapter, I provide a synopsis of how historical ecology has been and can be used as an approach to examine the possible effects of farming and other pre-Columbian subsistence practices on once pristine Caribbean island environments. With new research pushing back the antiquity of domesticated and non-domesticated plants and animals both within the Caribbean and the surrounding mainland regions, how does the expanded temporal framework allow for a more nuanced view of ancient human intervention and the effects they may have had on island environments? Further, what might we expect to see in terms of landscape transformation in the Antilles as a result of farming compared to the circum-Caribbean or other island regions given gaps in various datasets commonly used in historical ecology approaches?

An historical ecology framework

The field of historical ecology recognizes that humans must learn about and adapt to their environments, subsequently leading them to influence, modify, and/or impact their environments over time to some degree through various cultural and technological processes. Historical ecology harnesses data derived from both the social and natural sciences and includes, but is not limited to, paleoecology, archaeology, historical accounts, anthropology (e.g., oral traditions), and modern biological studies. The goal of subscribers is to coalesce what can be very disparate lines of evidence into a more cohesive analysis of what humans were doing on the landscape through time and discern whether changes observed can be attributed to their presence or influence (e.g., Balée 1998, 2002; Crumley 1994; Fitzpatrick and Keegan 2007; Kirch and Hunt 1997; McGovern et al. 2007). According to Balée (2006: 76), historical ecology as a research program has several postulates: 1) nearly all environments on earth have in some way been affected by humans; 2) there are no genetic bases for humans to have decreased or increased the diversity of species and other environmental structures; 3) the disturbance of landscapes differs between societies depending on various political, cultural, and socioeconomic criteria; and 4) the interaction of humans and their environments across time and space can be studied integratively.

Historical ecology has been used in a variety of settings, although it is particularly amenable to island environments. This is because islands can serve as ecological ‘model systems’ (see Kirch 2007; Vitousek 2002), resulting from distinct changes in habitat (i.e., land surrounded by water), general remoteness, and isolation from humans until relatively recently when the development of seafaring technologies and navigational skills allowed them to surpass the aquatic perimeter (e.g., see Fitzpatrick 2013). The colonization of islands by humans also institutes what is called ‘ecological succession’—a concept deriving from systems theory and cultural ecology—that posits a ‘renewal’ or succession of guilds of organisms after disturbance (Balée 2006: 83). According to Balée (2006: 84), “ecological succession in historical ecology

can be called landscape transformation (anthropogenic succession).” As archaeologists and other scholars have recognized, historical ecology has great potential to uncover and understand long-term changes that humans had on ancient environments and provides an important framework for deciphering when and how these occurred (for some examples in island and coastal regions, see Fitzpatrick and Keegan 2007; James 1995; Kirch and Hunt 1997; Lawson et al. 2005; Rick and Erlandson 2008; Swetnam et al. 1999).

In the Caribbean, there is increasing recognition that Amerindian groups were influencing their environments to some degree, though in many respects the data are still lacking to adequately determine what these effects may have been. Earlier attempts to examine and synthesize these issues from an historical ecology perspective (see Fitzpatrick and Keegan 2007; Fitzpatrick et al. 2008; also see Fitzpatrick and Intoh [2009] and associated papers in a special issue of *Pacific Science*) focused largely on the exploitation of marine resources and terrestrial animals through time without much emphasis on how the introduction of plants and widespread food production may have altered island environments, though the data until recently was even more sparse. As such, my goal is not to reiterate those findings here (particularly given that this volume is primarily concerned with farming), nor to provide a detailed overview of farming practices in the Caribbean before and after European contact, which is ably done by many other authors in this volume. Instead, I provide a brief overview below of the general trends that are seen with major population dispersals in Caribbean prehistory in regards to subsistence; examine what we see (or might expect to find) in the region compared to the surrounding mainland areas (see Silverman and Isbell 2008) or other islands (particularly the Pacific) if intensive food production was taking place; and then discuss the potential for employing an historical ecology perspective for farming in the pre-Columbian Caribbean.

Colonization and the prehistoric dispersal of plants and animals into the Caribbean

While the earliest dates for human colonization of any of the Caribbean islands are found on Trinidad ca. 8200–7700 cal BP at the sites of Banwari Trace and St. John (see Pagán Jiménez et al. 2015), the island was connected to the South American mainland during the Early Holocene and today is only between 9–14 km away from Venezuela. This makes the colonization history quite different than the rest of the eastern Caribbean where intervisibility was not possible until reaching Grenada or other islands to the north. Trinidad was essentially an extension of South America for much of its geological, biological, and cultural history, and a major reason why the radio-carbon dates here are as much as a millennium or more older than the rest of the Caribbean.

It is generally accepted that the first colonization of islands not adjacent to South America took place in Cuba and Hispaniola sometime between

6500–5500 cal BP (Fitzpatrick 2015). The earliest of these Archaic groups (previously known as the “Lithic” or “Casimiroid” groups *sensu* Rouse 1986) were presumably hunter-gatherer-foragers who originated from somewhere in Central America, although the paucity of sites and good radiocarbon chronologies for this dispersal make it difficult to pin down the exact nature of these groups. The presence of ground and flaked stone tools and exploitation of both terrestrial and marine resources, particularly larger animals such as sea turtles and manatees, suggests that these peoples were opportunistic and fairly nomadic foragers who did not bring with them any plants or animals, or practice food production (Veloz Maggiolo and Vega 1982).

Later between ca. 5000–4000 cal BP there appears to be a different dispersal of populations that settled in Cuba, Hispaniola, Puerto Rico, much of the northern Lesser Antilles, and Barbados, though they may have simply been descendants of earlier Archaic peoples. There is great diversity in the distribution and types of archaeological assemblages found at Archaic sites, though most contain lithic material and are found along the coast with a narrow range of resources used (e.g., limited number of shellfish taxa). There are exceptions, of course, including the Plum Piece site on Saba—located inland and at higher elevations—that was used to seasonally exploit land crabs and birds (Hofman et al. 2006). Antigua in particular has dozens of Archaic sites (Davis 2000) whereas most other islands in the Lesser Antilles have only one or two, largely due to the presence of tool-quality chert deposits. Once thought to be mostly mobile foragers, there is a growing body of evidence that Archaic groups were more sedentary than once thought, produced the Caribbean’s first pottery (see Keegan 2006; Rodríguez Ramos 2008), and managed and/or cultivated their own crops, including *maranguéy* (*Zamia* spp.), yellow sapote, and wild fig (Newsom and Wing 2004). Recent starch grain analysis on stone artifacts recovered from sites in French Guiana and Trinidad have pushed back in time the cultivation and processing of maize (*Zea mays*) (ca. 7700 cal BP in the South American specimens and ca. 5400 cal BP for Trinidad), sweet potato (*Ipomoea batatas*) (ca. 6500 cal BP in Trinidad), chili peppers (*Capsicum* spp.), and several other food plants (Newsom and Wing 2004; Pagán Jiménez et al. 2015). What these data show is a much earlier and varied suite of cultivars exploited by Caribbean Amerindians during the Archaic Age than previously assumed. This should not be particularly surprising given that there were at least 83 native species, including sweet potato, manioc, tobacco, cacao, pineapple, and peppers that were domesticated in Amazonia by the time of European contact, with another 55 Neotropical species imported and cultivated (Clement et al. 2015). As Clement et al. (2015: 2) also note, “In Amazonia, the transition from primarily foraging to developed farming systems occurred by ca. 4000 BP, as formerly casual cultivation in home gardens and managed forests was transformed by larger and more settled populations.” This general time-frame coincides with the movement of Archaic groups from South America into the Antilles.

The Ceramic Age, which begins ca. 2500 cal BP and extends up to European contact, is characterized by a widespread and intentional movement that originated from somewhere in South America and covered the Lesser Antilles and Puerto Rico, but appear to have terminated their movements north and westward. The reasons for this are unclear, though it could be the result of Saladoid groups wanting to avoid dense Archaic populations on Hispaniola or perhaps oceanographic affects that limited sea travel (Callaghan 2008; Fitzpatrick 2013; Giovas and Fitzpatrick 2014). The latter explanation has some merit, for Jamaica and the Bahamas have no evidence for human occupation earlier than ca. 1400 BP and the Caymans none (Scudder and Quitmyer 1998). Regardless, these first Saladoid groups produced exceptional pottery, exploited a wide range of marine resources, especially finfish and mollusks (e.g., see Newsom and Wing 2004), translocated both domesticated and undomesticated animals from South America such as the guinea pig (LeFebvre and deFrance 2014), agouti, peccary, and opossum (Giovas et al. 2012), and intensively cultivated a wide range of plants for food. These included manioc (*Manihot esculenta*), maize, sweet potato, and many others (e.g., see Mickleburgh and Pagán Jiménez 2012; Newsom and Wing 2004; and various chapters in this volume). Plants were also used for their pharmacological or psychoactive properties, including the hallucinogenic snuff *cohoba* (*Anadenanthera peregrina*) (Pagán Jiménez and Carlson 2014). Saladoid villages were often situated along the coast, though on some islands they are found inland in a variety of habitats. Over the course of the Ceramic Age there are a number of differences observed in the archaeological record in terms of pottery styles, subsistence strategies, and other modes of cultural behavior that led to the settlement of previously uninhabited islands, the development of intricate exchange systems (Hofman et al. 2008), and the differential rise of social complexity between sub-regions (e.g., north and south). This is most readily observed with Taíno groups who encountered Columbus in 1492 and whose influence—spiritually, politically, and ideologically—was spreading across the Antilles rapidly in the centuries before contact (Oliver 2009). However, populations in the southern islands exhibited a much different suite of cultural behaviors and material culture than what is seen in the north, particularly the Greater Antilles, even on the cusp of Columbus' arrival.

As the archaeological record demonstrates, there is a much earlier use of various cultivars in northern South America and the Caribbean. This evidence, which primarily derives from archaeobotanical remains (e.g., phytoliths, starch grains) recovered from artifacts such as stone pestles, milling stones, and microliths, or embedded in dental calculus (e.g., Berman and Pearsall 2008; de Armas et al. 2015; Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez et al. 2015), is indicative of native groups' ability to more effectively manage plants and their important role in ensuring survivability and population stability in island environments (e.g., Phoca-Cosmetatou 2011). It should be noted, however, that the current archaeobotanical evidence does not yet provide a means to assess the scale and intensity of food consumption.

So, while starch grains from maize and other plants are now being found on artefactual and human remains earlier, more frequently, and in varying locations, what this actually means in terms of daily consumption for Amerindians is unknown.

Given that most islands worldwide required the movement of both domesticated and wild plants to ensure successful colonization and long-term settlement, there is a need to identify the presence of non-native taxa in palaeoecological and archaeological records in conjunction with associated technologies (e.g., grinding or other processing implements), which can help to discern the diversity and extent of subsistence strategies and possible environmental changes that occurred through time. The main issue is a lack of high resolution data to answer these kinds of questions in detail, though this is slowly improving.

What does the existing Caribbean paleoenvironmental evidence suggest about farming, landscape transformation, and impact on island ecologies? A number of studies have examined ancient environmental changes that occurred across parts of the Holocene that suggest linkages between the presence of charcoal particles and human occupation prior to archaeological evidence for settlement, for example, as well as how humans may have responded to climatic changes (e.g., Rivera-Collazo 2015; Rivera-Collazo et al. 2015; Siegel et al. 2015). However, what is lacking in these records is palaeoenvironmental evidence for the presence of non-native plant taxa (e.g., cultivars) that would indicate the movement and cultivation of economically important plants.

Overall, what the evidence suggests is that over time humans were likely causing the extinction or extirpation of animals such as birds (Steadman and Franklin 2015), various species of reptiles and mammals (Fitzpatrick and Keegan 2007; Soto-Centeno and Steadman 2015; Steadman et al. 2015), and possibly sloths (Steadman et al. 2005), altering landscapes with fire (see Caffrey and Horn 2015; Caffrey et al. 2015; Higuera-Gundy et al. 1999; Siegel et al. 2015), and having to develop social mechanisms to react to changing climatic regimes (Cooper and Peros 2010; Rivera-Collazo et al. 2015).

Caribbean farming: expectations and comparisons

The historical ecology of farming in the Caribbean is still in its infancy. This is likely due to a number of factors, including widespread and abrupt decline of native Amerindian populations after European contact for which there is a major void in traditional ecological knowledge (TEK) often used in historical ecological studies. In addition, there is also a paucity of good paleoenvironmental and archaeobotanical evidence that would attest to the introduction of exotic plants to islands at various points in time. Though more recent studies show that cultivars such as maize, sweet potato, manioc, chili peppers, arrowroot (Marantaceae), common bean, maranguey (*Zamia* sp.), and many others, including wild varieties such as arrowhead (*Sagittaria lancifolia*),

were processed and consumed by Amerindians (Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez et al. 2015) earlier and more intensively than once thought, how these were cultivated and managed are also still somewhat of an enigma. Evidence thus far is patchy, but suggests peoples were practicing arboriculture, managed home and forest gardens, and created agricultural plots that probably included raised mounds (Pagán Jiménez 2013; Rouse 1992: 12) like the small and circular (~30 cm high and 1 m or so in diameter) ones described by Las Casas (1971) in the mid-1500s (see also Newsom and Wing 2004: 167). The question remains as to what we should expect to see in the Caribbean in terms of harvesting practices, water capture and management, landscape modification, storage, and control of surplus when food production takes place, especially when compared to surrounding mainland areas where many of these same plants were utilized. Estimating the degree of social and technological advancements has important recourse for determining levels of environmental impact that may have occurred and developing research designs to target specific areas for survey that fulfill the requisite criteria (e.g., slope, soil quality, proximity to watersheds) for growing crops.

Given that maize was domesticated in Mesoamerica and spread relatively rapidly to South America and later, the Caribbean islands and southern and eastern parts of North America—and with numerous other plant taxa such as sweet potato and manioc observed in the archaeological and historical record—what differences are there that would help to better understand Caribbean farming practices and resultant social behaviors? Most models of how food production develops and changes involve the use of more sophisticated technologies through time to feed growing populations and maximize caloric output per hectare (e.g., see Roosevelt 2014). These technological advances often include the use of draught animals; capture of moisture or harnessing of water (e.g., mounding); fertilizers; home gardens (Figure 1.1A) using slash and burn and field rotation to allow for nutrient regeneration that involve growing multiple crops in one area (e.g., known as *conuco* or *milpa*); and land modification in the form of terracing, and/or wet or dry field cultivation over more expansive areas. Eventually, as populations grow, agricultural societies typically build irrigation networks, canals, or a combination of these; store their surplus in granaries or other communally based structures such as waterports and artificially constructed enclosures to capture and harvest marine resources; construct monumental architecture; and develop complex sociopolitical systems that govern organized labor, manage surplus, and taxation, and that eventually lead to systems of weights and measurements, calendars, and writing or other forms of communication (e.g., the Incan *quipu*).

Besides the llama and vicuña in South America, and the dog, no other New World domesticated species served as pack animals, with none of these known to have been harnessed and used for tilling fields. Across the circum-Caribbean peoples developed novel and sophisticated systems for growing maize,



Figure 1.1 A. Modern Mayan home garden in the Yucatan, Mexico (photo by Traci Ardren); B. Incan circular farming terraces, Sacred Valley of the Incas (Peru) (Wikimedia); C. Stone terraces at Chincero, Sacred Valley of the Incas, Cusco, Peru (Wikimedia).

including terracing on hillsides (epitomized in the New World by the Inca; see Londoño 2008; Mosblech et al. 2012; Wright 2006; Figure 1.1B and C) and the construction of irrigation canals and associated networks to divert water from existing river systems like that in the American Southwest (e.g., Purdue et al. 2010; Schaafsma and Briggs 2007; Wills and Dorshow 2012). This is best exemplified by the Hohokam in Arizona who diverted water from the Salt and Gila rivers to irrigate more than 20,000 hectares, the most expansive use of irrigation north of Mesoamerica until after European contact (Hunt et al. 2005). Other crops such as manioc were grown in larger fields and mounded ridges like that seen at Ceren in El Salvador (Sheets et al. 2011). The Mayan agricultural system of *milpa* involving forest gardens was also exceptionally productive (e.g., Fedick 1996; Ford and Nigh 2009; Lentz et al. 2015). Once thought to be a backwater of complex societies, new evidence from across Amazonia has also now demonstrated the presence of causeways and roads, raised field agriculture, anthropogenic soils, canals, ditches cut between the meandering bends of rivers, wetland earthworks, fish weirs, and artificial ponds (Clement et al. 2015: 4–5).

Apart from the very complex and innovative ways that various cultivars were grown and harvested across the circum-Caribbean mainland regions, there are well-documented cases of emerging complexity in the form of social hierarchies with priestly elites, monumental architecture (e.g., Incan cities, Mayan and other Mesoamerican pyramids, cliff dwellings in the American Southwest, massive mound construction with Mississippian cultures, shell mounds and ring formations in the Southeastern United States), and a slew of other social and technological advancements that enabled populations to grow and civilizations to develop independently across wide swaths of the New World. While it is not possible here to outline each and every example of these changes as observed in the archaeological record, it is worth noting that they are coincident with large scale food production of many of the same plants which are known in the Caribbean prehistorically. So, why are these same elements of complexity absent or rarely found in the Antilles?

With new data indicating that plant cultivation in the Caribbean islands was both more diverse and earlier than once thought, it is likely that many archaeologists have simply not looked for (or perhaps overlooked) evidence of intensive cultivation practices and structures for capturing and/or storing aquatic resources. As a result, there are certainly many opportunities for archaeologists to examine whether some of the same strategies were used by Amerindians in the Antilles as elsewhere in the circum-Caribbean and that would suggest possible linkages between them. But would such evidence be so elusive as to escape the eyes of scholars for so long?

While farming is certainly practiced by non-state level societies worldwide, it is curious why there is a distinct absence of nearly all of the other common indicators of social complexity in the Antilles that would lead to the rise of more state level civilization so common in the surrounding mainland areas. While there are virtually no islands in the world where state level societies independently develop (Okinawa and Crete are two notable exceptions), the Pacific shows a great deal of complexity in both dryland and wetland agricultural systems (Kirch 1995; Figure 1.2), earthwork formations (e.g., Liston 2009) and other types of landscape modification construction and movement of megaliths (Hazell and Fitzpatrick 2006; Hunt and Lipo 2011), and stone construction (e.g., Wallin 1993) (Figure 1.3), despite the great distances and remoteness involved. This has led some scholars, for example, to label Tonga and Hawaii as 'Archaic States' (Clark et al. 2014; Kirch 2010). While most of the islands in the Caribbean are quite small (<300 km²), particularly many of those found in the Bahamas and Lesser Antilles, others such as Cuba, Hispaniola, Jamaica, Puerto Rico, and Trinidad exceed 4800 km² in size, with nutrient-rich arable land, rivers, lakes, and other sources of permanent fresh water, and easy access to a diverse array of terrestrial and aquatic resources. Given that the only known terraces and irrigation networks identified in the Caribbean are found in the Greater Antilles (Puerto Rico), does this suggest that there are environmental or social variables that make these places more conducive or necessary to complex



Figure 1.2 Wetland taro cultivation on Futuna, South Pacific (photo by Patrick V. Kirch).

forms of food production? If interaction networks were so pervasive (e.g., Hofman et al. 2008), why are some of these advanced technologies found only in rare instances despite their connections to other islands and mainland areas? How can historical ecology contribute to answering these questions?

Synopsis and future directions

What the historical ecology of the Antilles and surrounding mainland areas suggest is that there is currently a lack of sufficient data—particularly paleo-environmental and anthropological, but also archaeological—that would help examine the effects that humans and farming had through time in the Caribbean islands. On the surface, the Caribbean may not readily fit the model of how farming traditionally develops through time, as it seems distinctly different from what has been documented in much of the surrounding mainland areas that include portions of North America, Mesoamerica, and South America. This is despite a similar suite of cultivars being harvested and what would appear to be sufficient land area, population density, resource availability, and connections to some of these areas through time by peoples in the Antilles. Archaeological evidence shows clear connections to South America from the Mid-Holocene onward, especially during the Ceramic Age (Hofman et al. 2008), though the intensity and timing of some population dispersals is still uncertain (Fitzpatrick 2015; Siegel et al. 2015). Nonetheless, it is curious why a steady influx of plant introductions that began in the Archaic Age by at least ca. 5000–4000 BP—and which intensified during

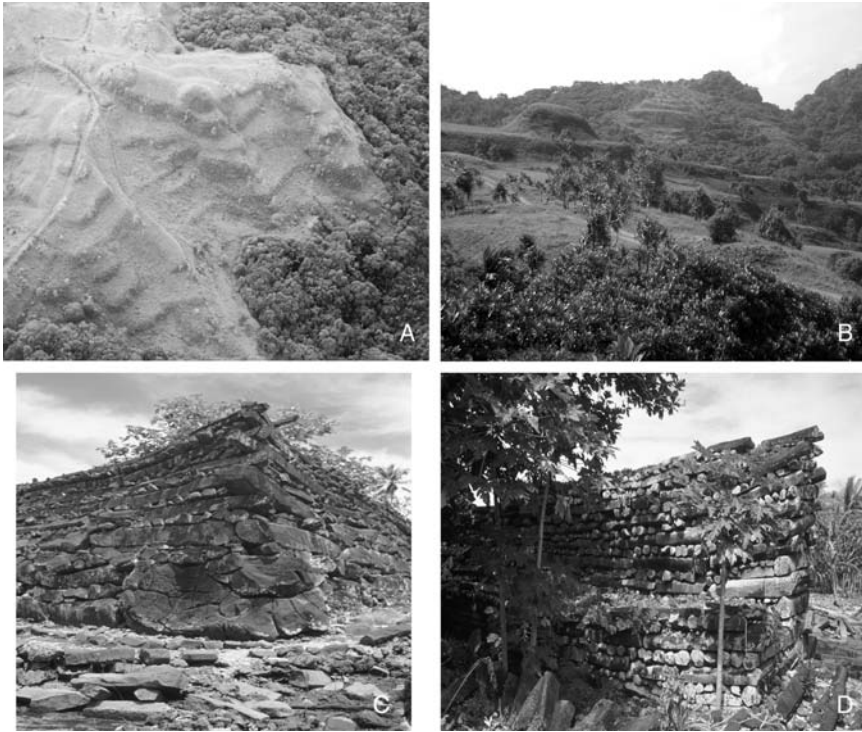


Figure 1.3 Monumental earthwork formations and architecture in the Pacific Islands. A. Earthwork formations in Aimeliik, Palau (courtesy of C. Emesiochel); B. Terraces E of Debel A Ngchemiangel Bay, Palau, Micronesia (photo by C. Emesiochel); C. Columnar basalt columns used to construct residential features at the site of Nan Madol, Pohnpei, Micronesia (photo by Scott M. Fitzpatrick); D. Columnar basalt columns used to construct residential features at the site of Nan Madol, Pohnpei, Micronesia (photo by Scott M. Fitzpatrick).

the Ceramic Age post-2500 BP, along with the increased movement of both domesticated and wild animals from South America (such as the guinea pig that originated from the Andean region)—did not apparently involve the same cultivation or management strategies or lead to a similar level of social complexity as seen elsewhere.

It is worth noting that in the Caribbean there is virtually no use of megaliths or monumental architecture, with the possible exception of plazas or ballcourts (*bateys*) in the northern islands (though these are comparatively small and less elaborate than what is found in most parts of the circum-Caribbean and other major island regions) (e.g., see Alegría 1983; Torres et al. 2014). Apart from a possible case in Hispaniola (Fewkes 2009¹; Krieger

1930: 488; Rouse 1992: 1²), there is no evidence for the construction of large-scale irrigation networks. The use of terracing is known, but to date has only been recorded in Puerto Rico (Ortiz Aguilú et al. 1991 and Oliver et al. 1999). There is also a paucity of evidence for the long-term storage of plant foods (e.g., granaries, though root crops pose different preservation issues than cereals) and a lack of more permanent or semi-permanent devices for capturing fish such as weirs or artificially constructed stone ponds that have been identified in many other island or coastal environments around the world (e.g., Costa-Pierce 1987; Godwin 1988; Kikuchi 1976; McQuade and O'Donnell 2007; Moss et al. 1990) (Figure 1.4). While less common, aquaculture, involving the growing or capture of shellfish or other marine taxa like clam gardens in the Pacific Northwest (e.g., Caldwell et al. 2012; Deur et al. 2015), and possibly similar strategies are seen at the Pineland site (Marquardt and Walker 2001) and Mound Key (V. Thompson, pers. comm. 2015) in coastal Southwest Florida using shell mound construction (Figure 1.5). These types of remains are virtually undocumented in the Caribbean, with the exception of a single report of groups in Cuba who apparently kept freshwater fish in pens (Sauer 1966: 58). Could it be that as vertical hierarchies emerged in the Caribbean, elements of more communal and egalitarian social structures (traditions) were maintained, which may help explain the disparity seen in farming practices, technologies, and between the islands and surrounding mainland regions? This is a research question that requires further inquiry.

Overall, the historical ecology of the Caribbean islands is complex, with numerous gaps in datasets that require further investigation to provide a more nuanced understanding of how humans were influenced by and affected their landscapes. While there is evidence from the zooarchaeological record that Amerindian groups were impacting marine and other animal resources through time (Blick 2007; Carlson and Keegan 2004; Fitzpatrick and Keegan 2007; Keegan et al. 2003; Steadman et al. 2015; Wing 2001), this was uneven, with some island populations appearing to have no major impact on finfish or shellfish populations (Carder and Crock 2012; Giovas et al. 2013; Poteate et al. 2015). The limited palaeoenvironmental data from cores in the Caribbean (e.g., Siegel et al. 2015), while tantalizing in terms of proposing an earlier colonization of some islands hundreds or thousands of years before the archaeological evidence, relies largely on the presence of increased charcoal particles and changes in vegetation regimes. Unfortunately, there is no indication yet of pollen or other micro- or macrobotanical remains deriving from cultivars that unequivocally precede human arrival as documented through archaeological evidence. Essentially, when the current data of pre-Columbian plant and animal use are collated for the Caribbean, they show some degree of impact on local biotas, especially birds and various terrestrial animals that were extirpated or driven to extinction. Impacts to marine environments also occur, though there are as many if not more cases of what would appear to be sustainable harvesting of shellfish and



Figure 1.4 Fish ponds and traps in the Pacific: A. fishpond at Honaunau; B. Fishing weir at Maeva; C. Makaha at Heeia; D. Aerial view of Makaha at Heeia (all photos courtesy of Damion Sailors).

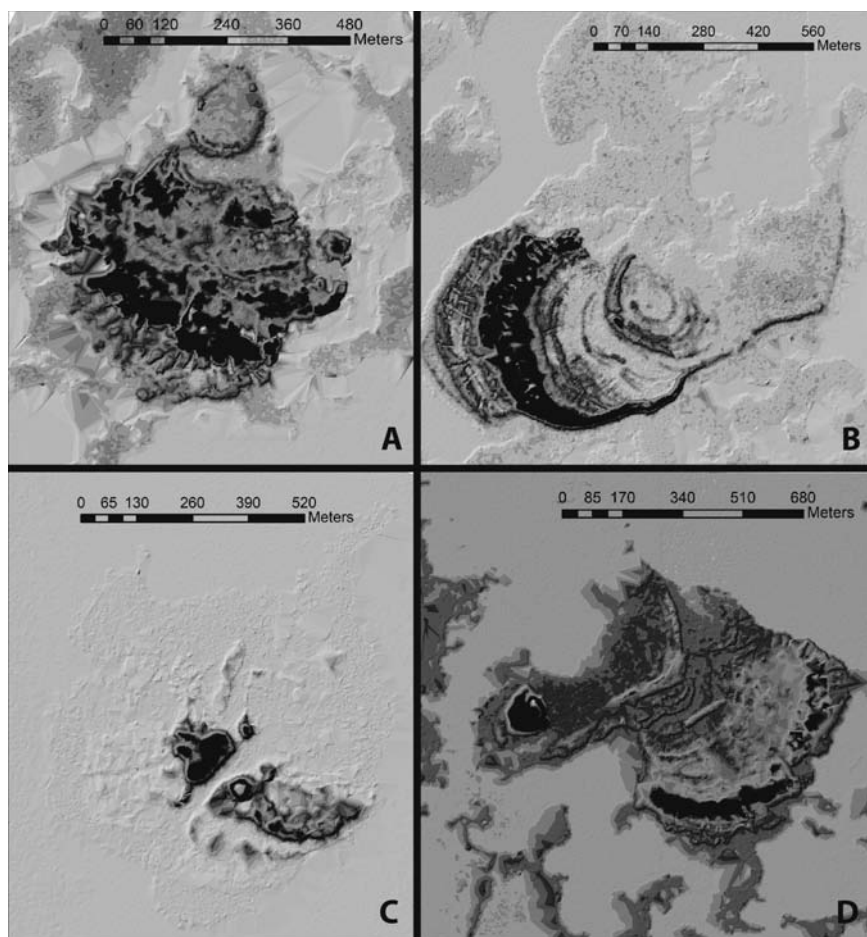


Figure 1.5 LIDAR image map of Mound Key, Florida, showing a central main canal, linear shell causeways, and orthogonal subsidiary canal (courtesy of Victor Thompson).

finfish. Moreover, in terms of farming, the lack of many elements typically seen in more complex societies such as monumental architecture and large-scale landscape alteration points to a focus on the use of garden plots and in some cases more expansive field agriculture, but would have had a much smaller impact on local environments compared to what is seen elsewhere in the circum-Caribbean. Future research may alter this perspective, but the data currently indicate that food management systems were less pernicious and/or perhaps more sustainable than many of their mainland cousins where devastating impacts and conflict were common features.

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Notes

- 1 According to Fewkes (2009: 50), Andreas Morales (citation derived from Hakluyt's collection, v. 301) stated that in the lake region of Haiti, peoples here would "practice a system of irrigation" when rain was sparse and that "in all of these regions are fosses or trenches, made of old time, whereby they convey the water in order to water their fields, with no less art than do the inhabitants of New Carthage and the Kingdom of Murcia."
- 2 From Oviedo y Valdés (1959: 13–18) who described irrigation systems being used in the drier southwestern part of Hispaniola.

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2 Humanizing the landscapes of the Lesser Antilles during the Archaic Age

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Introduction

The shift from a food-collecting to a food-producing way of life has been one of the central areas of research in anthropology and archaeology for decades (Adams 1962; Braidwood and Reed 1957; Brush and Turner 1987; Childe 1951; Cohen 1977; Cowan and Watson 1992; Gebauer and Price 1992a; Geertz 1963; Harris and Hillman 1989; MacNeish 1955; Piperno and Pearsall 1998; Price and Gebauer 1995; Reed 1977; Roth 1887; Sauer 1952; Struever 1971). Much of this interest was inspired by late eighteenth-century ideas of Thomas Malthus concerning the relationship between population density and the availability of necessary resources. When, how, and why early food-production methods were incorporated into the repertoire of survival strategies are once again questions defining current research, especially in attempting to disentangle social-classificatory schemes from assumed subsistence patterns. There are so many exceptions to the dichotomy of mobile *bands* of hunters-gatherers-foragers-collectors vs. settled *tribes and more socially complex communities* of farmers that these equations need to be demonstrated rather than assumed (Ames 1994; Lepofsky et al. 2015; Moseley 1975). In doing so, we will gain greater understanding of the timing; process; conditions; and social, economic, and environmental contexts of early food production.

In this chapter, we will address early anthropogenic landscapes as contexts within which human groups gradually transitioned from an exclusive reliance on food collecting to the incorporation of food production in their repertoire of survival strategies. Rather than representing a revolution in lifeways and attendant changes in social relations, political organization, and belief systems, we argue that the humanization of landscapes was a gradual process of landscape learning, modification, and eventual management that created places of opportunities and generally predictable resources. This process is characterized as an intergradation of cumulative human-derived landscape transformations, ranging from incidentally modified to systematically and purposely managed – all within the framework of variable

climate conditions. Modifying landscapes for the goal of increasing productivity is recognized by archaeologists and biologists as a form of human niche construction (Laland et al. 2001; Rowley-Conwy and Layton 2011; Smith 2011). We explicitly recognize the combined importance of human history and agency in the dynamics of ecosystem change.

The southern and eastern Caribbean islands between Venezuela and Puerto Rico framed our case study. We collected environmental cores from wetlands and a lake on selected islands of the southern Caribbean and Lesser Antilles (Figure 2.1). Data from three of the islands reveal human-modified landscapes approximately 3000–3500 years prior to when many archaeologists currently believe humans colonized this portion of the Caribbean.

Current views on Archaic colonization and modifications to landscapes of the Lesser Antilles

Good archaeological evidence of Archaic occupations is notoriously sparse on the islands of the Lesser Antilles between Tobago and Antigua. Data collected in our environmental coring project show that the paucity of known Archaic sites in the Lesser Antilles is a product of sampling and not a reflection of colonization or migratory strategies. Taphonomic factors have impacted the preservation or visibility of Archaic sites, especially compared to the later and apparently larger and more numerous Neolithic sites in the same region (Table 2.1).

Despite these caveats, archaeologists continue to propose models whereby settlers from South America bypassed most of the Lesser Antilles in their colonization of the Caribbean (Callaghan 2003, 2010; Fitzpatrick 2013). In the absence of systematically collected archaeological and environmental data, we argue that it is premature to promote colonization models based on notions of aimless drift, accidental voyaging, or random walking.

Table 2.1 Taphonomic factors impacting the preservation and visibility of Archaic sites in the Lesser Antilles

<i>Taphonomic factor</i>	<i>Impact</i>	<i>Source</i>
Volcanism	Sites buried beneath volcanic deposits of variable depths.	Allaire 1989; Armstrong 1980; Fisher and Heiken 1982; Roobol and Smith 1976; Westercamp and Traineau 1983
Historic-period erosion	Sites buried beneath colluvial or alluvial deposits of variable depths.	Current project; Richardson 2004; Sauer 1966; Sheridan 1973; Watts 1987
Postglacial relative sea-level changes	Sites under water as paleocoastlines are inundated.	Armstrong 1980; Cooper and Boothroyd 2011; Murray-Wallace and Woodroffe 2014; Ramcharan 2004; Toscano et al. 2011

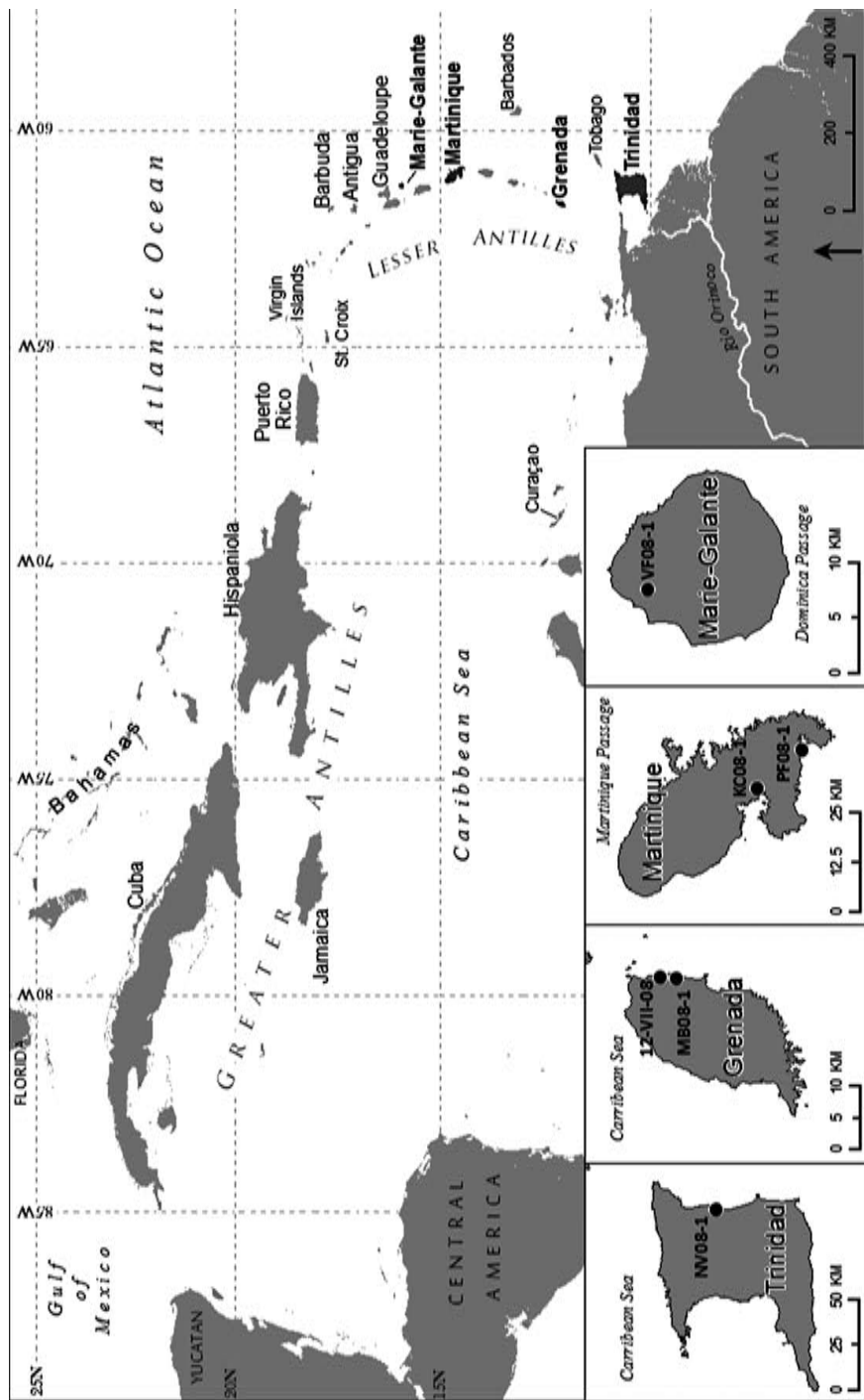


Figure 2.1 Map of the Caribbean Basin. Environmental cores were collected from Trinidad, Grenada, Curaçao, Barbados, Martinique, Marie-Galante, Antigua, Barbuda, and St. Croix. Cores discussed in this chapter came from Trinidad, Grenada, Martinique, and Marie-Galante (inset) (prepared by Kathryn Carlson).

Boomert's (2000) comprehensive review of Caribbean archaeology provides the most convincing archaeologically, ethnohistorically, and ethnographically informed case for the systematic use of edible and otherwise ethnobotanically useful plant taxa in the Early Archaic of Trinidad. He emphasized the broad-spectrum subsistence adaptations by these earliest colonists to Trinidad. Drawing on the work of Harris (1989), Boomert made the fundamentally important point that the earliest form of food production, or "protocultivation," was linked to "ecosystem manipulation," whereby ethnobotanically useful taxa were nurtured and promoted (Boomert 2000: 93–95). It is unclear to what extent the first cultigens on Trinidad were developed locally or imported from lowland South America. The best evidence for the systematic collection and processing of plant resources during the Early Archaic comes from the Banwari Trace and St. John artifact assemblages dating to c. 8000 cal BP (Boomert 2000: 55–68; Pagán Jiménez et al. 2015).

Brian Hayden's point made long ago is important to keep in mind:

[t]hat simple manipulation of the productivity of wild species is commonplace among hunter-gatherers throughout the world, either via transport, fire, irrigation, sowing, transplanting, or stocking. Such strategies may have been used by hunters-gatherers throughout history. I suggest that what requires explanation is not this type of elementary manipulation, but intentional behaviors *calculated to change* the physical properties of the wild species.

(Hayden 1992: 11; emphasis in original)

Evidence for purposeful modification and management of landscapes and the native biota in them does not necessarily signal horticulture or agriculture. As Deborah Pearsall emphasized, "Increasing abundance of some foods over others, reflecting human-aided dispersal and[/or] protection of species, would be an indication of incidental domestication" (Pearsall 1995: 161). These practices of incidental domestication may represent forms of protocultivation. Further, it is a mistake to apply universal explanations to the origins of agriculture and processes of domestication. It is abundantly clear that management of landscapes, cultivation, and eventual agricultural practices emerged in contexts of unique histories and environmental circumstances, which certainly may be compared cross-regionally for potentially underlying similar processes (Harris and Hillman 1989; Smith 1995).

In the remainder of this chapter, we provide paleoenvironmental evidence for human modified and managed landscapes in the Lesser Antilles dating to the early to mid-Holocene. We discuss the implications for: (1) understanding Archaic subsistence strategies, (2) early colonizers as fundamentally important agents of change, and (3) processes of landscape learning linked to the earliest forms of landscape modification and management. The first colonizers to new places, we argue, produced incidentally modified

landscapes, which eventually graded into actively managed landscapes. The first colonizing groups to the Lesser Antilles created anthropogenic landscapes, c. 5000 cal BP. In occupying new places, first colonists had variable impacts on landscapes, ranging from overexploitation of resources to selectively nurturing and promoting native plant taxa. While modifying and managing landscapes is not necessarily a form of food production or horticulture, we argue it is one of the preconditions in the process of plant domestication.

Humanization of the Lesser Antillean landscapes by colonists dating to about 5000 cal BP

In our larger project entitled *Socionatural Landscapes of the Eastern and Southern Caribbean*, we are investigating modifications to landscapes through the full range of human history, from first colonization through early European settlement. We selected nine islands between Venezuela and Puerto Rico to address historical-ecological relations over approximately eight millennia of human occupations (Siegel 2018). The success of this kind of study in the Caribbean was first demonstrated by what we now consider to be a pilot project on Puerto Rico (Siegel et al. 2005).

In total, we collected 24 environmental cores from wetlands and one lake. Cores from four of the islands yielded data that allowed us to reconsider current initial colonization models and land-use histories. Proxies for past environmental conditions were preserved in the cores (Siegel 2018). The compositional makeup of these landscapes is necessarily different with the arrival of humans than those of the pre-human-occupied landscapes.

Criteria necessary for reconsidering colonization models centered around multiple proxies for human-derived interventions on landscapes that pre-dated earliest known and reasonably well-documented archaeological sites on the islands. For this discussion, we made one exception. One of the cores collected from Nariva Swamp on Trinidad yielded proxies for anthropogenic landscapes not quite as old as the earliest dates from the Banwari Trace and St. John archaeological sites. On Trinidad, therefore, the Banwari Trace and St. John sites represent the earliest documented human occupations for that island. The human-modified landscapes that we identified in Nariva Swamp predate the earliest documented anthropogenic landscapes in the Lesser Antilles by 3000–3500 years. The first people who ventured into the Lesser Antilles no doubt originated in Trinidad or the Paria Peninsula of eastern Venezuela, or both. In this regard, the Nariva Swamp coring data represent an ethnobotanical and historical-ecological knowledge base that the first colonists carried with them to the Lesser Antilles.

Proxies used to identify anthropogenic impacts to landscapes included microfossils of pollen, phytoliths, and charcoal particulates and sediment

chemistry. Shifting combinations of landscape disturbance indicators and ethnobotanically useful plants, especially significant increases in these taxa and/or charcoal particulates, were viewed within the framework of circum-Caribbean climate history when distinguishing between natural and cultural events in our paleoenvironmental records. Elevated values of disturbance indicators, ethnobotanically useful plant taxa, and charcoal particulates during mesic periods of the Holocene were interpreted to be products of human activities. Spikes in charcoal concentrations and disturbance indicators with little to no changes in percentages of ethnobotanically useful taxa during xeric periods of the Holocene were attributed to such natural events as forest fires resulting from lightning strikes. Disentangling natural from cultural impacts in Caribbean paleoenvironmental records is addressed in Siegel (2018).

Environmental cores collected from Grenada, Martinique, and Marie-Galante (Guadeloupe) produced proxies for anthropogenic landscapes predating unambiguous archaeological evidence for human occupations on those islands. Results of the Nariva Swamp, Grenada, Martinique, and Marie-Galante cores are detailed elsewhere and will only be summarized here (Duncan et al. 2018; Farrell et al. 2018; Jones et al. 2018a, 2018b; Siegel et al. 2015).

Nariva Swamp, Trinidad

A 3.2 m core collected from a red and black mangrove estuary within Nariva Swamp was dated to c. 7060 cal BP (AA82681). Charcoal-concentration values were exceedingly high, especially from 280–195 cm. Ethnobotanically significant and disturbance-indicator taxa were well represented from the base to approximately 180 cm (Tables 2.2 and 2.3).

The lower section of the core with high charcoal concentrations dates to the mid-Holocene period of very wet conditions (Curtis et al. 2001; Higuera-Gundy et al. 1999; Mangini et al. 2007). We argue that sustained, elevated charcoal during the mesic conditions of the mid-Holocene, combined with somewhat higher percentages of Poaceae and considerably higher values of *Cecropia* and Moraceae, indicate that local clearings were being maintained (Athens et al. 2014; Burney 1997a, 1997b; Burney et al. 1994; Pyne 1998). Ethnobotanically useful taxa associated with this period include Fabaceae, Anacardiaceae, *Spondias*, *Coccoloba*, and Sapotaceae (Tables 2.2 and 2.3).

The paleoplant communities and the anthropogenic indicators vary by degree between Nariva Swamp, Trinidad and the Lesser Antillean contexts. Many of the plant taxa were present in all cores across the islands. Similarities in anthropogenic patterns reflect adaptive strategies developed in mainland South America or Trinidad, which were applied to new places reflecting a form of landscape learning as first colonizers dispersed rapidly through the island chain.

Table 2.2 Project evidence of early proxies for human-caused landscape interventions in Trinidad and the Lesser Antilles

<i>Island/core</i>	<i>¹⁴C date (BP)/lab sample number</i>	<i>Proxies for early human intervention</i>
Trinidad/Nariva Swamp	6160±70/AA-82681	Disturbance indicators: Poaceae, <i>Cecropia</i> , Moraceae, sustained elevated charcoal concentrations. Ethnobotanically useful taxa: Fabaceae, Anacardiaceae, <i>Spondias</i> , <i>Coccoloba</i> , Marantaceae, Sapotaceae.
Grenada/Lake Antoine	4860±45/AA-91728	Disturbance indicators: <i>Cecropia</i> , Moraceae, sustained elevated charcoal concentrations. Ethnobotanically useful taxa: Anacardiaceae, <i>Bursera</i> , <i>Spondias</i> , Moraceae, Sapotaceae.
Grenada/Meadow Beach	4420±40/AA-84799	Disturbance indicators: Asteraceae, Cyperaceae, Poaceae, <i>Cecropia</i> , Moraceae, sustained elevated charcoal concentrations. Ethnobotanically useful taxa: Poaceae, Solanaceae, Anacardiaceae, Arecaceae, <i>Bursera</i> , <i>Coccoloba</i> , Moraceae, Myrtaceae, Rubiaceae, Marantaceae, Sapotaceae, <i>Spondias</i> sp.
Martinique/Baie de Fort-de-France	4420±30/Beta-341060	Disturbance indicators: <i>Cladium</i> , Asteraceae, Cyperaceae, Poaceae, Moraceae, sustained elevated charcoal concentrations. Ethnobotanically useful taxa: Poaceae, Moraceae, Sapotaceae.
Marie-Galante/Vieux Fort	4380±60/AA-84884	Disturbance indicators: Asteraceae, Cyperaceae, Poaceae, <i>Cecropia</i> , sustained elevated charcoal concentrations. Ethnobotanically useful taxa: Poaceae, Arecaceae, Sapotaceae.

Grenada

Two cores revealed anthropogenic landscapes earlier than what the archaeological record indicates for the presence of humans on Grenada (Boomert 2000; Bullen 1964). A 5 m core from Meadow Beach was dated to c. 6060 cal BP (AA82678). Between c. 6060 and 5010 cal BP charcoal concentrations were low and represent a baseline pre-human-disturbance environment. Ethnobotanically useful taxa seemed to be relatively well represented in the

Table 2.3 Scientific and common names of plant taxa listed in Table 2.2

<i>Scientific name</i>	<i>Common name</i>
Asteraceae	Aster or Composite family
<i>Cladium</i> sp.	Sedge
Cheno-ams	Chenopod and amaranth families
Cyperaceae	Sedge family
Poaceae	Grass family
Solanaceae	Nightshade family
<i>Cecropia</i> sp.	Pumpwood
Moraceae	Mulberry family
Myrtaceae	Myrtle family
Rubiaceae	Madder family
Fabaceae	Legume or pea family
Anacardiaceae	Cashew family
Apocynaceae	Dogbane family
Arecaceae	Palm family
<i>Bursera</i> sp.	West Indian birch
<i>Spondias</i> sp.	Genus in the cashew family: Hog plum, Java plum, Spanish plum, Jamaica plum, Acaiba
<i>Coccoloba</i> sp.	Sea grape
Marantaceae	Maranta family
Sapotaceae	Sapote family

pollen and/or phytolith counts during this early to mid-Holocene era: Poaceae, Solanaceae, Arecaceae, *Bursera*, Moraceae, Marantaceae, Myrtaceae, Rubiaceae, Sapotaceae, and *Spondias* (Tables 2.2 and 2.3). However, low pollen and phytolith concentration values for these plants combined with a high sedimentation rate over the thousand-year period does not support evidence for human selection of ethnobotanically useful taxa prior to 5010 cal BP (Table 2.4). Arecaceae is well represented in the phytolith concentrations in the basal portion of the core. Sustained and elevated charcoal concentration values are bracketed by median dates of 5010 and 3010 cal BP (Tables 2.2 and 2.3). This is during a period documented to be among the wettest in Caribbean climate history, so it is unlikely that these high charcoal concentrations were the result of widespread natural fires (see also Burney et al. 1994; Siegel et al. 2005). Further, sedimentation rate for this c. 2,000-year date range is quite low (Table 2.4). Arecaceae (palm family with edible fruit) pollen and phytolith concentrations declined significantly above 325–300 cm, shortly after the onset of large-scale burning. It is conceivable that the earliest colonists to the area overexploited palms, thereby restructuring the local plant community. The 1700- to 2400-year period of human-induced burning and landscape modifications documented in the Meadow Beach core most likely represent the impacts of first colonizers to Grenada.

An 8.4 m core from Lake Antoine produced a date of c. 8930 cal BP (AA91730, 737 cm). No evidence of human inputs was identified at that

Table 2.4 Sedimentation rates for the cores discussed in the text

Core/ ¹⁴ C sample depths	¹⁴ C date ranges (median cal dates, BP)	Sedimentation rate (cm/yr) ^a
Nariva Swamp, 103–209 cm	3490–6720	.0328
Nariva Swamp, 209–250 cm	6720–7060	.1205
Meadow Beach, 216–331 cm	3010–5010	.0382
Meadow Beach, 331–492 cm	5010–6060	.1533
Lake Antoine, 146–312 cm	1240–1980	.2243
Lake Antoine, 312–612 cm	1980–5600	.0828
Lake Antoine, 612–700 cm	5600–8140	.0346
Lake Antoine, 700–737 cm	8140–8930	.0468
Baie de Fort-de-France, 230–575 cm	1610–5000	.1017
Baie de Fort-de-France, 575–675 cm	5000–5740	.1351
Pointe Figuier, 128–222 cm	390–2740	.0404
Marie-Galante, 63–206 cm	600–1930	.1075
Marie-Galante, 206–256 cm	1930–3120	.0420
Marie-Galante, 256–414.5 cm	3120–4960	.0861
Marie-Galante, 414.5–656 cm	4960–6530	.1538

^a Bolded values associated with earliest evidence of anthropogenic landscapes.

depth, thereby representing a baseline pre-anthropogenic landscape. A spike in charcoal, increased percentages of Arecaceae, and somewhat elevated herb totals (disturbance indicators) were documented at 700 cm, which dated to c. 8140 cal BP (Beta-377883). Paleoclimate records indicate a period of dry conditions between approximately 10,000 and 7200 cal BP (Curtis et al. 2001). The charcoal spike and disturbance indicators dating to c. 8140 cal BP therefore may reflect a natural fire event(s) associated with the period of dry conditions seen in the paleoclimate records (Banner et al. 1996; Curtis 1997; Curtis and Hodell 1993; Hodell et al. 1991; Leyden 1985).

Sustained concentration values in charcoal were documented by 600 cm. A date of c. 5600 cal BP (AA91728) was obtained from organic sediment at 612 cm. Elevated values of pollen from disturbance indicators (*Cecropia*) and pollen and phytoliths of economically useful taxa (Anacardiaceae, *Bursera*, Moraceae, Sapotaceae, and *Spondias*) were also documented (Table 2.2). The increased presence of charcoal coincided with a major decline in Arecaceae. The Meadow Beach and Lake Antoine data are consistent regarding the timing of human-derived disturbances on Grenada no later than c. 5600–5010 cal BP, at least 3,000 to 3,500 years earlier than what the archaeological record currently indicates for the presence of humans.

Martinique

A 7 m core from a wetland along the Baie de Fort-de-France was dated to c. 5740 cal BP (AA82676) with no proxies for anthropogenic inputs at that

time (625–575 cm). Charcoal values began to increase in the upper portion of the basal zone by 600 cm along with increases in pollen concentrations of *Cladium* sp., Poaceae, Cyperaceae, and Moaceae colonizing taxa associated with open, cleared spaces. One pollen sample revealed a spike in Sapotaceae, an edible-fruit-bearing tree. Preserved plant matter from 575 cm was dated to c. 5000 cal BP (Beta-341060). Increases in Asteraceae and Cyperaceae pollen were documented by approximately 500 cm. These herbaceous families include weedy invaders of cleared, open areas. The pollen and charcoal assemblage from this zone represents an actively managed anthropogenic landscape. The interpreted signal of human activity from c. 575–425 cm occurred during the mesic conditions of the mid-Holocene.

Two possible Archaic sites (Boutbois, Godinot) have been identified in northern Martinique (Allaire and Mattioni 1983). On reexamination, these sites may or may not be of Archaic age; they may be special-purpose aceramic sites dating to the Ceramic age, although the lithic assemblages from the two sites are similar in character to Archaic sites documented on Trinidad (Bérard 2006a, 2006b; Boomert 2000). Charcoal collected from Boutbois produced a date range of 1700–1320 cal BP (2 σ), clearly postdating the Archaic age (Bérard 2006b). The best evidence for early human activities on Martinique comes from the Baie de Fort-de-France core, considerably earlier than current archaeological data from the island.

Marie-Galante (Guadeloupe)

A nearly 7 m core collected from a wetland along Rivière du Vieux Fort was dated to c. 6530 cal BP (AA82675). Disturbance-indicating vegetation was reduced and particulate charcoal almost wholly lacking, representing a non-anthropogenic landscape. By 400 cm sustained increases in particulate charcoal concentrations were documented. This period of elevated charcoal concentrations was bracketed by the dates of c. 4960 and 3120 cal BP, which is associated with the mid-Holocene period of wet conditions in the Caribbean. Pollen concentration values for invasive weedy and economically useful taxa increased at this time. Disturbance-indicator taxa included Asteraceae, Poaceae, Cyperaceae, and *Cecropia* (Tables 2.2 and 2.3). With the clearing of local forests plants of economic value were selectively spared and encouraged, resulting in what were previously low pollen concentrations with higher values. Economically useful plant taxa included Arecaceae (palm family) and Sapotaceae (Sapote family). It is not clear what accounts for the replacement of the *Rhizophora* (red) by the Combretaceae (white) mangrove communities, although evidence of rising sea level by 464 cm may be linked to the reduction in red mangrove at about 410 cm. Major increases in charcoal concentration values beginning at 400 cm may or may not be related to the shift in mangrove communities. Red mangrove has been documented to be a superior fuel wood (Morton 1965); however, its diminished presence in the Marie-Galante pollen record predates by an unknown

number of years the significant increase in probable anthropogenic fires. The charcoal and pollen data reflect a human-modified if not actively managed landscape by c. 5000 cal BP, considerably earlier than archaeological evidence for human occupations on Marie-Galante.

Summary

Paleoenvironmental data collected from a core in Nariva Swamp, Trinidad indicate that humans were modifying and perhaps managing landscapes in that region nearly 2000 cal yr before initial colonization of the Lesser Antilles. Certainly, floristic communities in many of the Lesser Antillean islands were recognizable to the first colonists, clearly attested to by the many similarities in plant taxa documented in the pollen and phytolith data. The landscape-learning curve was not demonstrably steep for pioneering groups entering the islands for the first time.

Data collected from cores on Grenada, Martinique, and Marie-Galante are consistent with the timing of initial human colonization approximately 5000 cal BP, although a date from the Lake Antoine, Grenada core suggests human presence as early as c. 5600 cal BP. Evidence from this mid-Holocene era consists of considerable and sustained increases in charcoal particulates and shifts in pollen and phytolith spectra related to plants representing disturbances or perturbations to landscapes and increases in economically useful taxa. These data represent initial human occupations of the islands, whereby landscapes were modified and eventually managed.

From the perspective of landscape ecology, human-derived perturbations created greater heterogeneity in ecosystem structure than what was present prior to colonization. Native economically useful plants most likely were nurtured in managed landscapes as first colonists created places recognizable to them as home. Newly occupied and modified places were manifestations of transported landscapes, not in the sense of physically bringing in new species from elsewhere but in a cognitive and behavioral sense; knowledge of and lifeways practiced in their previous homelands were drawn upon in the colonization and humanization of landscapes (Thomas 2008).

It is clear too from our findings that first colonizers to new places in the Lesser Antilles had variable impacts on landscapes. With the arrival of first colonizers to Grenada, palms appeared to have been overexploited resulting in significant declines in pollen or phytolith concentrations of those plants. On Martinique and Marie-Galante, first colonizers were more strategic in their encouragement of selected native plant taxa. With geographic expansion from south to north through the archipelago, early foragers became more experienced with new landscapes and how to manage resources in the process of modifying landscapes. This form of landscape learning and management practices created predictable ethnobotanically useful resource patches. In contrast to Rouse's (1986) early ideas about Saladoid farmers bringing in the first cultigens and management practices, we now believe

that Archaic foragers initiated the process of domesticating landscapes. As observed by Gebauer and Price (1992b: 8), "Foragers became farmers rather than being replaced by them." We do agree with Rouse (1986, 1992) that Saladoid colonists brought their farming practices with them from lowland South America. Those farming practices were grafted onto landscapes that had been humanized, domesticated, and managed for millennia prior to their arrival.

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3 The neolithisation of the northeastern Caribbean

Mobility and social interaction

Corinne L. Hofman, Reniel Rodríguez Ramos, and Jaime R. Pagán Jiménez

Introduction

Recent multi-disciplinary research suggests that the first incursions into the northeastern Caribbean began to take place in the 4th to 3rd millennia BC (Boomert 2000; Hofman et al. 2014; Rodríguez Ramos 2010). The earliest forays into the islands were undertaken by groups that developed strategies for adapting to first the maritime and then the insular environments, and by developing local networks while maintaining continuous social relationships with their place of origin on the South and Central American mainlands. These networks, presumably based on kinship, marriage, competition, exchange, and other societal processes, served as the platform upon which later interactions were established and maintained by Huecoid and Saladoid communities. This chapter aims to challenge the long-held presuppositions of an abrupt 'neolithisation' in the islands and will advance new hypotheses on their earliest occupations and the inter-group interactions that were registered during this early phase of Caribbean history in Puerto Rico and the Lesser Antilles.

Archaic Age mobility and social interaction

Various regions in South and Central America may have served as source areas for the pre-Columbian insular Caribbean (Figure 3.1) (Hofman and Hoogland in press; Hofman et al. 2011; Rouse 1992; Wilson et al. 1998), which can be dated to ca. 7800 BP on the island of Trinidad located in the southern portion of the Antillean region. Although a single Joboid spearhead found near Biche on Trinidad suggests that humans were active on this island (then still part of the mainland) since much earlier, i.e. around 10000 cal. BP, the oldest traces of verified human occupation of the Antilles can be assigned to what has been traditionally called the Archaic Age (Harris 1991).

The sites of St. John and Banwari Trace in Trinidad, dated to ca. 8000 years ago, provide the earliest evidence for human presence in the insular



Figure 3.1 Map of the Lesser Antilles and Puerto Rico (edited by M. Hoogland).

Caribbean (Boomert 2000: 57; Pagán Jiménez et al. 2015; Reid 2011). The items of material culture found at sites from this period usually consist of randomly flaked stones and bone artefacts (projectile points and fishhooks), some associated with fishing and hunting, as well as formally shaped ground stone tools used for plant processing. Trinidad and Tobago have revealed a total of 29 Archaic Age sites until now, including 11 midden sites (Boomert 2000: 49, 54–55). These sites were attributed to the Ortoiroid tradition as defined by Rouse (1992), including the Banwarian (7000–2500 BC) and

Ortoiran (1500–300 BC) subseries. Recent evidence from St. John indicates that important economic plants such as maize (*Zea mays*), sweet potato (*Ipomoea batatas*), achira (*Canna* sp.), and chili pepper (*Capsicum* sp.), among others were imported from the continental landmass and grown on a regular basis (Pagán Jiménez et al. 2015). This showcases that there were long-established traditions of plant husbandry in the southernmost insular Caribbean before the incursions to the islands to the north took place, as has also been observed on the neighbouring mainland. This leads to the argument that it is very likely that there was never a ‘pre-agricultural’ period in the islands (Pagán Jiménez 2011; Rodríguez Ramos 2010, 2016; Rodríguez Ramos et al. 2013).

In contrast to Trinidad, in the rest of the southern Lesser Antilles only Tobago and Barbados have yielded remains potentially attributable to the Archaic Age (Boomert 2000; Fitzpatrick 2011). The site of Heywoods on Barbados, for example, has provided a set of early radiocarbon dates (3280–2940 cal. BC, 2530–2200 cal. BC and 2320–1750 cal. BC) suggesting that this is one of the oldest sites known so far between Trinidad and Puerto Rico (Drewett 2006; Fitzpatrick 2011). On Martinique, the sites of Le Godinot and Boutbois, previously reported (Allaire and Mattioni 1983) as Archaic Age sites, have lately been questioned in terms of their cultural-temporal attribution (Bérard, pers. comm. 2010).

This paucity of archaeological sites in the Windwards may be related to problems with site preservation and visibility (e.g. Crock and Petersen 2001; Davis 1982; Delpuech 2004; Delpuech et al. 2001; Fitzpatrick 2012; Hofman and Hoogland 2015, in press; Hoogland et al. 2015; Litman 2001; Watters et al. 1992, 2001). The possibility of early contexts in the southern Lesser Antilles is, however, illustrated by a recent coring program, which has revealed anthropogenic fires and vegetation disturbance in nearly the entire southern portion of the archipelago, dating to more than 5500 years ago (Feller et al. 1992; Siegel et al. 2015a, 2015b). Unfortunately, aside from this paleoecological evidence and the isolated find on Barbados, there have been no early archaeological sites clearly documented between Tobago and Guadeloupe. Thus, until these sites are located, also other possibilities must be considered as to the peopling of the insular Caribbean, i.e. that Archaic Age canoers bypassed the southern islands, going straight to the northern Lesser Antilles and the Greater Antilles where there is ample evidence of human occupations in this time period (Rodríguez Ramos 2010; Rodríguez Ramos and Pagán Jiménez 2006). Parallel to an eventual population movement from the south, incursions from the Greater Antilles into the northern Lesser Antilles have been registered as well (Crock et al. 1995; Hofman et al. 2007; Veloz Maggiolo 1972; Wilson et al. 1998). One impetus for such a movement may have been the search for high quality flint, notably that of Long Island offshore Antigua, which has been found as far west as Puerto Rico (Hofman et al. 2006, 2011, 2014; Rodríguez Ramos et al. 2013).

Archaic Age evidence in Puerto Rico and the northern Lesser Antilles

Based on chronometric data, the Archaic Age in Puerto Rico and the northern Lesser Antilles has been tentatively divided in an Early Archaic phase (ca. 3500 and 2000 BC), a Middle Archaic phase (ca. 2000 and 800 BC), and a Late Archaic phase (ca. 800 BC and AD 200) (see also Hofman et al. 2014).

Early Archaic phase

On Puerto Rico the sites of Maruca, Angostura, Cueva Ventana, and Puerto Ferro (Vieques) have provided the earliest evidence of human occupation to date. The timing of these earliest occupations is still a matter of debate, given that its initial assay, obtained from Angostura which goes back to 5460–4340 cal. BC, has been deemed problematic primarily given its unusually high standard deviation and its lack of correspondence with the rest of the dates obtained from this site. More secure evidence of human presence comes from the anthropogenic events recorded in Laguna Tortuguero, just east of Angostura, with dates going back to 3520–3030 cal. BC, which have been associated with anthropogenic landscape alteration events, similar to those previously described for the Lesser Antilles (Siegel et al. 2015b). By the end of this period, Puerto Rico was occupied in its four cardinal ends as evidenced by the sites of Maruca in its south, Angostura, Paso del Indio and Cueva Ventana in the north, Puerto Ferro in the east (Vieques), and Ortiz and Hacienda La Baume in the west. These sites have been located in a wide array of settings, from active alluvial valleys (Maruca and Paso del Indio) to caves (Cueva Ventana) and estuarine environments (Ortiz site).

It is during this period that the earliest evidence for cultivars has been documented in Puerto Rico, being obtained from Maruca, Puerto Ferro and Cueva Ventana, the only sites from which starch grains have been analysed thus far (Pagán Jiménez 2009, 2011, 2013; Pagán Jiménez et al. 2005). Food plants such as maize, manioc (*Manihot esculenta*), sweet potato, wild yam (*Discorea* sp.), achira, and *marunguey* (also known as *guáyiga* or *coontie*; *Zamia* sp.), have been identified among others. It is important to note that these plants have been associated with a food producing tradition that includes edge-ground cobbles and milling stones as its most conspicuous components, together with a suite of irregularly shaped manos and bases (Figure 3.2).

In the Virgin Islands, two early radiocarbon measurements from the Krum Bay site, St. Thomas suggest an initial occupation of the island during this phase (Figueredo 1974; Gross 1976; Lundberg 1989: 84; Casper Toftgaard, pers. comm. 2016). On Antigua, large quantities of flint artefacts and debitage were recovered from sites on the island, and Antiguan flint is found also at most, if not all, Early Archaic Age sites in the northern Lesser Antilles. The main flaked lithic template at the early Antiguan sites consisted of blade production, although randomly shaped freehand flakes and cores are also noticeable (Crock et al. 1995; Knippenberg 1999; van Gijn 1993).

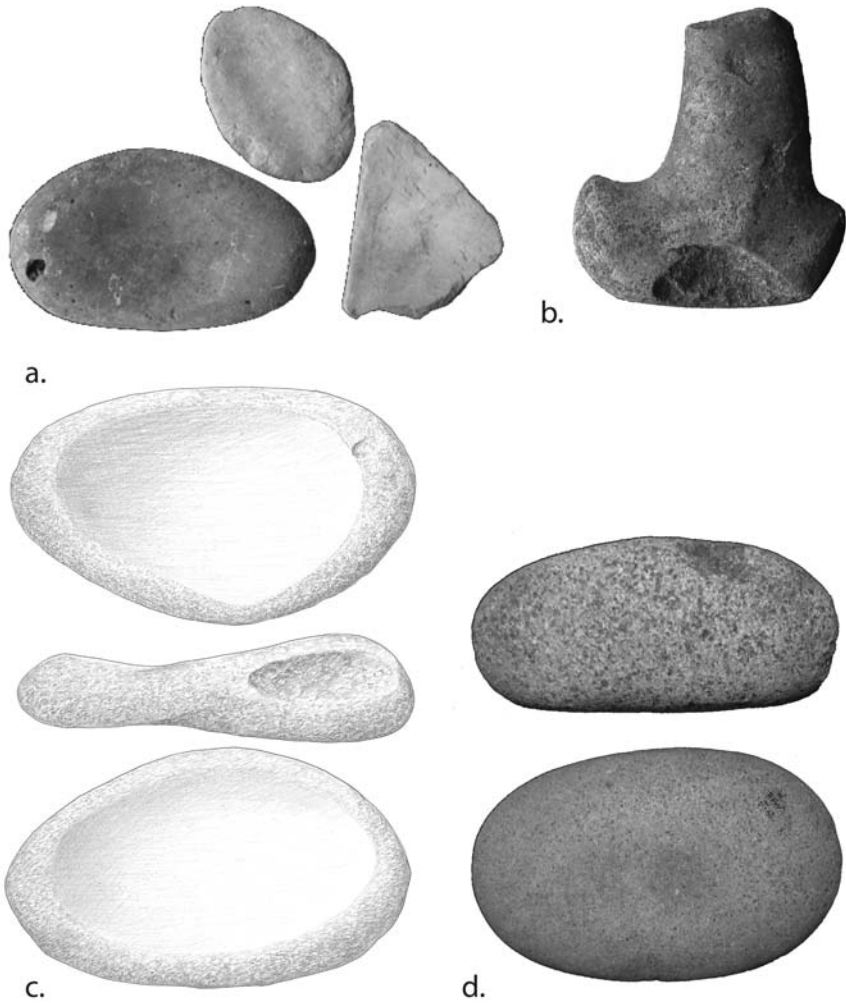


Figure 3.2 Multi-functional ground stone tools for grinding, rubbing, pounding and crushing plants from a–c) Plum Piece (Saba) and d) Puerto Ferro (Puerto Rico) (Photos by C. Hofman and R. Rodríguez Ramos, image by M. Hoogland).

Large blades are only found on a few islands in the archipelago, of which Montserrat (The Upper Blake's site) located in the interior of the island at ca. 300 m amsl (Cherry et al. 2012) and Saba (The Level), also located in the interior of the island at ca. 400 m amsl (Hofman and Hoogland 2003). Unfortunately, no radiocarbon dates are available for these two sites, but the large prepared flint blades may eventually point to a date in the earliest Archaic Age occupation of the archipelago.

In the northern Lesser Antilles, the earliest Archaic phase is evidenced on St. Martin, at Etang Rouge (3318–3033 cal. BC and 3260–2926 cal. BC) and Pont de Sandy Ground 2 (2544–2188 cal. BC) (Bonnissent 2003, 2008); on Saba at Old Booby Hill cave (2160–1975 cal. BC) (pers. observ. Ryan Espersen and Corinne Hofman 2016), on St. Kitts, Sugar Factory Pier (2210–2090 cal. BC) (Armstrong 1978, 1980; Goodwin 1978), and on Antigua at Little Deep site (3106 cal. BC) and Twenty Hill (2910 cal. BC) (Davis 1982, 2000; Nodine 1990; Olsen 1976). Recently, human remains from this period were uncovered in the cave of Morne Rita on Marie-Galante dating to the start of 3rd millennium BC 3009–2876 cal. BC) (Fouéré et al. 2015).

Middle Archaic phase

It is during this period that Puerto Rico and the northern Lesser Antilles begin to report a marked increase in the number of settlements. In Puerto Rico, all the sites that were previously occupied continue to show evidence of human presence while new sites appeared, particularly in the northern and western portions of the island. Of particular importance is the evidence for new cave sites such as Cueva Río Hondo 1 which, as Cueva Ventana, is located in the karstic formation of the island. In the case of Cueva Ventana, there is evidence for the presence of rock art (pictographs and petroglyphs), some of which seems to be related to its Middle Archaic stage of occupation. These cave sites show the exploitation of the island's inland fauna for protein consumption, including land snails and riverine fish, together with *Neritina* shells, a conspicuous element in these early contexts. They also show the presence of mother-of-pearl artefacts, as has been noted in Cueva Tembladera, Cueva Ventana and Maruca.

During this phase, there is an increase in sites located in or near estuarine environments, most notably on Vieques (Verdiales I, Loma Jalova 3 and Caño Hondo) and southern Puerto Rico (Papayos, Jobos, Pastillo and Hacienda Teresa). These open-air sites show an emphasis on the consumption of a varied fauna, including turtles, fish and crabs mixed with shells among which *Lobatus gigas*, *Murex brevifrons*, *Cittarium pica* and *Arca* sp. predominate. Some of these shells, particularly *Lobatus*, were used to produce picks, gouges and scalers. These types of artefacts were combined with the aforementioned edge-ground cobbles and irregular grinding stones. Interestingly, it has been noted that some of these materials, particularly those recovered from eastern Puerto Rico and Vieques, show marked resemblances to those encountered on the Virgin Islands, as is evidenced by the finding of a celt akin to those documented in Grambokola Hill, and edge grinders of ochreous rocks almost indistinguishable from those of Krum Bay and Cancel Hill (Figueredo 1974; Lundberg 1989). Chert was being widely circulated between these sites, having likely been obtained from sources in the southwest and northwest of Puerto Rico. The main emphasis in the

distribution of this siliceous rock seems to have been the flakes, as there is a marked lack of cores at the consumption sites. This period also witnessed an increase in the production of bipolar flakes and cores, the latter of which were likely derived from pre-shaped flakes, as was documented by Walker (1980) in later contexts.

Various lines of evidence suggest that the islands southeast of the Anegada Passage, particularly Antigua and St. Martin, were densely occupied during the Middle Archaic Age. In the northern Lesser Antilles, sites dated to the phase as Norman Estate, Bay Longue 2, Pont de Sandy Ground 1 and 2, Saline d'Orient, Trou David 1 and 2, and Pointe du Bluff, St. Martin (Bonnissent 2008, 2013; Knippenberg 1999; Nokkert et al. 1995), Whitehead's Bluff and Flowers Avenue on Anguilla (Crock et al. 1995; Crock and Petersen 1999), Plum Piece, Great Point and Fort Bay Ridge on Saba (Espersen 2014, pers. comm. 2016; Hofman and Hoogland 2003; Hofman et al. 2006), the '*Strombus* Line' shell middens on Barbuda, like the River Site (Rousseau 2014; Watters 1980, 2001; Watters et al. 1992), numerous sites on Antigua, and the sites of Morel zero and Baie du Nord Est on Grande Terre, Guadeloupe. On the island of Basse Terre, the site of F     2 in the interiors of the Capesterre area recently revealed an important lithic assemblage dating to this phase (Fou     et al. 2011; Stouvenot and Casagrande 2015). This is quite remarkable as the majority of the sites are typically located along coastlines where people relied heavily on fish and shellfish exploitation (Bonnissent 2013; Newsom and Wing 2004: 80; Nokkert et al. 1995; Reitz 1989).

Settlements on Antigua are generally situated on the low-lying limestone plain along the northeastern coast of the island (Davis 2000). The presence of marine food resources from a variety of environments (i.e. mangroves, shallow muddy and sandy bottoms, and shallow rocky areas) and easy access to flint quarries situated along the northeast shore and at Flinty Bay on Long Island likely influenced these settlement locations, which are also drier than elsewhere on the island (Davis 2000: 91, 101). The site of Jolly Beach is rarely situated on Antigua's west coast (Davis 2000; Knippenberg 2001; van Gijn 1993). The west coast overlooks an extensive offshore marine zone with accompanying reefs and readily accessible fauna. Shellfish exploitation was focused on ca. eight major species. In addition to fish from shallow marine waters and some turtles and manatees, the Jolly Beach occupants also relied more on terrestrial fauna compared to others living along Antigua's shore (Davis 2000). The River Site on Barbuda located on the south coast along the '*Strombus* Line' at 2 m amsl has produced the largest amounts of molluscs in the region (Watters et al. 1992: 29; Rousseau 2014). Whitehead's Bluff is located on the northeastern tip of Anguilla at an elevation of 11–14 m amsl, exposed to the northeastern trade winds. The area is characterised by a karst topography that is sparsely covered by low, wind-stunted vegetation. The site lies approximately 80 m inland from the rock-bound shore to the west and an estimated 300 m from Windward

Point Bay to the east (Crock et al. 1995: 288). There is evidence of a heavy emphasis on shellfish, and shell was also intensively used for the production of tools like vessels, celts and celt preforms manufactured from *Lobatus gigas*. Ground stone tools include hammerstones, abraders and a mortar fragment. The site of Norman Estate is located in the northeastern part of St. Martin, in a relatively flat valley approximately 9 m amsl. It is enclosed by hills to the south and north. A small stream passes along the site to the west, and the northwestern and eastern seashores are about 1.5 km away. Subsistence data from this site suggest that the latter was primarily oriented towards reef fish and shells, with *Arca zebra* being the most common species. At Norman Estate, celts were made from *Lobatus gigas* columella fragments. Flakes made of volcanic rocks and waterworn pebbles have also been found (Crock et al. 1995; Nokkert et al. 1995). There is an absence of volcanic core fragments or cores at Norman Estate (Knippenberg 1999). Etang Rouge in the western part of St. Martin, on the peninsula of Terres Basses, had multiple occupations and provided next to the very early dates in the 4th millennium BC, also dates of 1800 cal. BC for its youngest layer. This layer is characterised by *Lobatus* sp. and particular stone implements (Bonnissent 2003, 2008, 2013; Martias 2005). Several hearths and cooking and consuming areas were identified, suggesting the repeated use of the area as a temporal campsite. The most prevalent bivalve species throughout the earliest phase are *Arca zebra* and *Codakia orbicularis*. *Lobatus* sp. constitute the majority of the gastropods followed by small quantities of *Cittarium pica*. A few shell and stone tools next to some flint implements comprise the tool-kit. On Saba, Plum Piece (1800–1500 cal. BC) and Fort Bay Ridge (1520–1445 cal. BC) date to this phase. Plum Piece is one of the rare sites in the northern Lesser Antilles that is situated in the tropical forest at an altitude of 400 m amsl. The site has a surface area of ca. 200 m² and has been preserved, in part, due to slope wash covering the archaeological deposit(s). A dense refuse deposit and shallow postholes evidence the intensive use of the area as a campsite around 3500 years ago. *Gecarcinus ruricola* (mountain or black crab), *Puffinus lherminieri lherminieri* (Audubon's shearwater), and pelagic and reef fish (e.g. *Epinephelus* sp., *Acanthurus* sp., *Lutjanus* sp., *Sparisoma* sp. and *Haemulon* sp. occur most frequently in the midden). Molluscs are nearly absent but the *Lobatus* shells, from which many adzes and celts were fashioned and used in wood working, probably had their meat extracted down at the beach in order to supplement the diet. Plum Piece is seen as a campsite with seasonal indicators and a forest-oriented activity spectrum (Hofman et al. 2006). Volcanic core fragments or entire cores are abundant at Plum Piece, as is also the case at Norman Estate on the neighbouring island of St. Martin. At Plum Piece flint was imported from Long Island, which is 150 km to the northeast of Saba. The almost total lack of cortex on the flint material suggests that cores arrived at the site in a pre-worked condition. However, the scarcity of cores suggests that they were transported further to enable tools to be made at other locations

(Hofman and Hoogland 2003). The majority of the tools were made of volcanic rocks, carried up the mountain from the seashore. Multiple purpose ground stone tools were used for grinding, pounding, battering, crushing and rubbing (Hofman and Hoogland 2003; Hofman et al. 2006; Nieuwenhuis 2008; van Gijn et al. 2008). Their sizeable number suggests that plants were processed at the site, either for consumption or for the extraction of fibres for the manufacture of baskets, mats or fish weirs. Use-wear analysis on flint implements displayed traces of siliceous plant materials (van Gijn et al. 2008). The perpendicularly oriented polishes were likely either related to subsistence tasks such as the peeling of tubers, or to craft activities like scraping plants to produce fibres for basketry making. The processing of grass seeds was also suggested, and certain plant species were probably cultivated in house or kitchen gardens (see also Newsom and Pearsall 2003; Pagán Jiménez 2011).

Late Archaic phase

During the latest Archaic Age phase, most of the northern Lesser Antilles and Puerto Rico were occupied. On Puerto Rico, this occupation seems to have extended up to at least AD 200 and in the northern Lesser there is evidence of occupation at the Bie Oriental site on St. Martin until AD 100. One interesting development in Puerto Rico has to do with the production of formally shaped ground stone artefacts, of which the conical manos are the most conspicuous. This type of artefact presents its most notable exemplars at the Cayo Cofresí site, located in the southern portion of the island. It has been found at other locations as well, most notably in the town of Salinas (Méndez 2014).

Evidence of late Archaic Age occupations has been found in a wide array of settings in Puerto Rico, again covering most of the island with sites in the north (Paso del Indio, Angostura and Cueva Río Hondo 1), east (Cueva María de la Cruz, Caño Hondo, Yanuel 9), south (Cayo Cofresí and Conector Coquí), and west (Ortiz site). In fact, it is from this latter site that the earliest directly dated human burial has been obtained, dating back to 40 cal. BC to cal. AD 240. Although estuarine contexts seem to have been the main occupational spaces for these late groups of the island, caves as well as active alluvial valleys continued to be occupied. In general, there seem to be no significant dietary, technological and settlement changes between this and the previous period, with the exception of the appearance of the aforementioned polished conical manos.

In the Virgin Islands, the main occupation at Krum Bay dates to 895, 750 and 105 cal. BC (Casper Toftgaard, pers. comm. 2016). In the northern Lesser Antilles, the late component of the site of Baie Orientale on St. Martin dates to this phase (Bonnissent 2013; Serrand 2001). On Saba, the recent dated Fort Bay Ridge site provided dates of 800–400 cal. BC and is therefore contemporaneous with Baie Orientale but also with Corre Corre Bay and

Smith Gut sites on St. Eustatius (Grant Gilmore et al. 2011; Versteeg 2000), Hichman's Shell Heap on Nevis (Wilson 1991), Pointe des Pies on Guadeloupe (Richard 1994) and the latest Archaic components of the Sugar Factory Pier site on St. Kitts (Armstrong 1978, 1980; Goodwin 1978; Walker 1980), which all date to the 1st millennium BC.

The late component of the Krum Bay site on St. Thomas also ranges in this same time period (Figueredo 1974; Gross 1976; Lundberg 1989: 84). Its location on a small sheltered bay with broad access to fishing grounds and pearl oyster beds is probably related to a focused collection strategy towards certain shellfish species and reef fish, and also to the exploitation of pearls during successive re-occupations of the site, spanning more than 1,000 years (Lundberg 1991: 74). No flint tools have been found at the site, but fine-grained rocks suited to producing flakes in a nonsystematic manner were recovered along with pebble hammerstones and grinders, bifacial celts or wedges, shell beads and disks, coral tools and *Lobatus* sp. columella tips (Lundberg 1989).

The Baie Orientale site on St. Martin covers ca. 500 m², and includes a number of camp areas associated with different activities such as shellfish cooking and consumption, and the manufacture of shell and stone tools (Bonnissent 2008, 2013; Bonnissent et al. 2001: 79–80).

Corre Corre Bay is the location where the earliest occupation on St Eustatius is recorded. A number of unmodified shells and shell tools, as well as coral and stone tool deposits were found that also contained flint from Long Island (Versteeg 2000). Shells from two locations within the deposit were dated to 410–208 cal. BC and 98 cal. BC to cal. AD 120.

A survey of the island of Nevis has generated evidence for two Archaic Age settlements, namely Hichman's Shell Heap and Nisbett (Wilson 1989). Both sites are characterised by shells, fish remains, and shell and stone tools. Both sites are located near fresh water supplies and large coastal reefs. A shell from the Hichman's Shell Heap site was radiocarbon dated to 605–290 cal. BC. Neither site produced ground stone artefacts, commonly found in the tool assemblages from this period on neighbouring islands (Wilson 1989: 435).

Paleoenvironmental data from St. Martin indicate a moist period during this latest phase of the Archaic Age which partly overlaps with the earliest dated Ceramic Age (Huecoid and Saladoid) sites in the northern Lesser Antilles and Puerto Rico (Bonnissent 2013; Hofman et al. 2014; Malaizé et al. 2011; Rodríguez Ramos 2010).

The Huecoid and Saladoid incursions

The reasons for the initial appearance of Huecoid and Saladoid ceramics in Puerto Rico and the northern Lesser Antilles are still under debate. On the one hand, it has been proposed that the appearance of these manifestations is the result of exploratory expeditions and eventually gradual migration of

new communities (Saladoid) from the mainland to settle on the islands permanently (Rouse 1992; Siegel 1993). On the other, it has been argued that, to an extent, both the Huecoid and the Saladoid might have been the result of local Antillean developments due to the continued interactions between the Archaic Age insular populations with peoples from the surrounding mainland (Hofman and Hoogland, in press; Hofman et al. 2007, 2011; Rodríguez Ramos and Pagán Jiménez 2006). In any sense, the available evidence indicates that local community groups were tied together through vast webs of dynamic social relationships in which various groups of peoples, perishable and nonperishable goods, and ideas as well as cultural and social practices, originating from both the islands and the mainland, syncretised and amalgamated over time, thus creating the complex cultural and social seascape of the Caribbean at this time (see Hofman and Bright 2010; Hofman et al. 2007, 2011; Rodríguez Ramos 2010).

The exploitation of the flint sources from Long Island in Antigua may have been an important stimulus in forming a northeastern interaction sphere (Hofman et al. 2014). Recent research and radiocarbon dating of the so-called Early Ceramic Age indicate that interaction with coastal South America and the Isthmo-Colombian area occurred in the region between Puerto Rico and Grenada somewhere between 400 cal. BC and cal. AD 200, encompassing the islands of Puerto Rico, Vieques, St. Martin, Montserrat, Antigua, Guadeloupe, Martinique, St. Vincent and Grenada. However, radiocarbon dates of 800 to 400 cal. BC, obtained for the sites of Hope Estate, St. Martin and Trants on Montserrat, if correct, suggest that these interactions may have happened somewhat earlier. This same time period thus partially overlaps with the later Archaic Age occupations of the northern Lesser Antilles and Puerto Rico, i.e. Trants and Hope Estate have given the earliest dates for the Huecoid and Saladoid occupations, ranging roughly between 800 and 200 cal. BC (Bonnissent 2008; Haviser 1989; Watters and Petersen 1995). Huecoid and Saladoid assemblages sometimes represent clearly separated stratigraphic units, but are often found as mixed deposits. Ceramics are found together with large amounts of lithic raw materials and ornaments and tools of semi-precious rocks and shell. Huecoid sites are located on Puerto Rico (e.g. Punta Candelero, El Convento and Hacienda Grande sites) (Rodríguez Ramos 2010); Vieques (La Hueca site) (Chanlatte Baik 1981); St. Croix (Prosperity, Sprat Hall and Christiansted) (Hofman pers. observ. 2016; Keegan and Hofman 2017; Toftgard pers. comm. 2016), Basse Terre and Grand Terre, Guadeloupe (Cathédrale and Gare Maritime de Basse-Terre, Morel, Anse Ste. Marguerite, and Anse Patate) (Arts 1999; Bonnissent et al. 2002; Clerc 1964, 1968, 1970; Hofman et al. 1999, 2004); Marie-Galante (Talliseronde and Folle Anse) (Barbotin 1987; Hofman et al. 1999); on Grenada (Pearls) (Petitjean Roget 1981; Hofman 1993, pers. observ. 2016); Montserrat (Trants) (Watters and Petersen 1995), and St. Martin (Hope Estate) (Haviser 1989; Hofman 1999). Curvilinear incised pottery with punctuations or crosshatching are one of the dominant

characteristics. The latter is more prominent in the Puerto Rican and Vieques traditions (Chanlatte Baik 1981, 1983; Hofman 1999). Typical vessel shapes resemble the bodies of aquatic animals (fish or turtles), showing zoomorphic *adornos* at the head side and the tail being decorated with curvilinear incisions. They have a second animal on top of the head, symbolising alter-egos (Hofman and Jacobs 2001).

Early Saladoid ceramics are characteristic for the coastal area of the Guianas (Wonotobo Falls, Western Suriname), the eastern coast of Venezuela and Margarita Island, and the Lesser Antilles, Virgin Islands and Puerto Rico (Boomert 1983; Hardy 2008; Rouse 1986, 1992; Rouse et al. 1985; Vescelius 1952; Vescelius and Robinson 1979). In the Lesser Antilles these ceramics have a combination of plain, white-on-red (WOR) painted, and zoned-incised crosshatched (ZIC) motifs (Rouse 1986; Rouse and Alegría 1990; Rouse and Morse 1999). Painted and ZIC pottery differs in material and shape as well as decoration and it has been suggested that they were used in different, probably ritual contexts, i.e. the ZIC ware being manufactured by a specialised religious sub-group within the Saladoid population (Rouse and Alegría 1990). However, this latter type of ceramics, found in the Antilles, has never been found isolated on the mainland.

Together with the proliferation and complexity of ceramic manufacture in the northern Antilles, the subsistence practices of the Huecoid and Saladoid peoples have been traditionally defined by the presence of clay griddles, which were always directly ascribed to the intensive cultivation and consumption of *Manihot esculenta* C. (Pagán Jiménez 2013). Following the previous scheme, manioc has been depicted as the main food source for the indigenous peoples of northern South America in pre-Columbian times (Rouse 1992), and this region was defined as the unique source for human migrations into the Antilles by this time period. Overall, it was believed that once these fully ceramic-bearing groups entered the Antilles, they also introduced agriculture and domestic plants for the first time to this region. However, these ideas have been contested not only on the basis of the documentation of the use of important domestic plants and cultivars during Archaic times, but also by similar lines of evidence obtained directly in the Huecoid sites of Sorcé/La Hueca and Punta Candelero in Puerto Rico (Pagán Jiménez 2007).

Plant managers and/or full horticulturalists

To date, there is more and more evidence that the Archaic Age settlers started domesticating the island landscapes immediately upon their arrival, practicing plant management of wild vegetable foods and cultivation of economic plants that were not only endogenous, but exogenous as well (Lundberg 1980; Newsom 1993; Newsom and Pearsall 2003; Newsom and Wing 2004; Terrell et al. 2003). Several sites in the northeastern Caribbean (Maruca, Puerto Ferro, Cueva María de la Cruz, and Cueva Ventana, Puerto

Rico; Krum Bay, St. Thomas, Hichman's Shell Heap, Nevis, Jolly Beach, and also Twenty Hill, Antigua) have yielded evidence of intensive collecting, management/cultivation and extra-territorial dispersal of food plants such as mastic-bully (or yellow mastic, canistel, Sapotaceae), corozo palm (Arecaeae), sea grape (*Coccoloba* sp.), cat's claw (*Celtis iguanaea*), marunguey, wild/domestic avocado (*Persea* sp.), common and wild bean (Fabaceae), maize, manioc, achira, arrowroot species, prickly ivy (*Smilax* sp.), cocoyam (*Xanthosoma* sp.), sweet potato and wild yam among others (see Newsom 1993; Newsom and Wing 2004: 84–86; Pagán Jiménez 2007, 2008, 2011, 2013; Pearsall 1989). Recent microbotanical analysis also revealed starch grains and phytoliths on grinding stones and multi-functional pounding and rubbing tools from Plum Piece. They showed the processing of domestic plants such as maize, sweet potato and probably annatto (*Bixa orellana*), together with the processing and use of wild ginger (Zingiberaceae), arrowroot and calathea (Marantaceae), and mountain cabbage (*Prestoea montana*) (Nieuwenhuis 2008; Pagán Jiménez 2011) (Figure 3.3). At this site one of the tools yielded evidence of the use of marunguey. This plant is not known to occur naturally in the Lesser Antilles, and may have been imported from the Greater Antilles where it is widely distributed (Pagán Jiménez 2011). This would suggest that marunguey acquired great economic or symbolic importance since early times, being distributed between the islands and likely circulating through particular interaction networks in which other plants and materials, peoples and ideas were also moving.

Interestingly, all of the Archaic Age sites in the northeastern Caribbean studied for ancient starch grains thus far, have clearly indicated the presence of important exogenous domestic species such as maize, sweet potato, manioc and common bean (among others), all of which were previously considered to have been introduced into the islands by the pottery-making Huecoid and Saladoid newcomers (Pagán Jiménez 2009, 2011, 2013). The presence of early cultivars in Trinidad, and in other potential source areas like the Isthmo-Colombian region and Central America, together with the recently generated evidence of fire episodes in the Lesser Antilles likely related to slash-and-burn activities show that many of the peoples that initially populated the islands had already been exposed to varied phytocultural traditions associated to these plants in continental America (Pagán Jiménez 2013; Pagán Jiménez et al. 2015). Furthermore, as has been argued elsewhere (Pagán Jiménez 2013; Rodríguez Ramos et al. 2013), it is quite possible that the presence of these traditions of plant husbandry were key for the initial occupation of the islands and for the further development of more complex agricultural practices.

This evidence for early food plant production and pan-Caribbean dispersal of crops accords well with recent hypotheses that characterise the Archaic Age peoples in Puerto Rico and the other Greater Antillean islands (labelled within the so-called 'pre-Arawak' Horizon) as true pottery makers who sometimes lived in permanent villages and had a tremendous impact on the

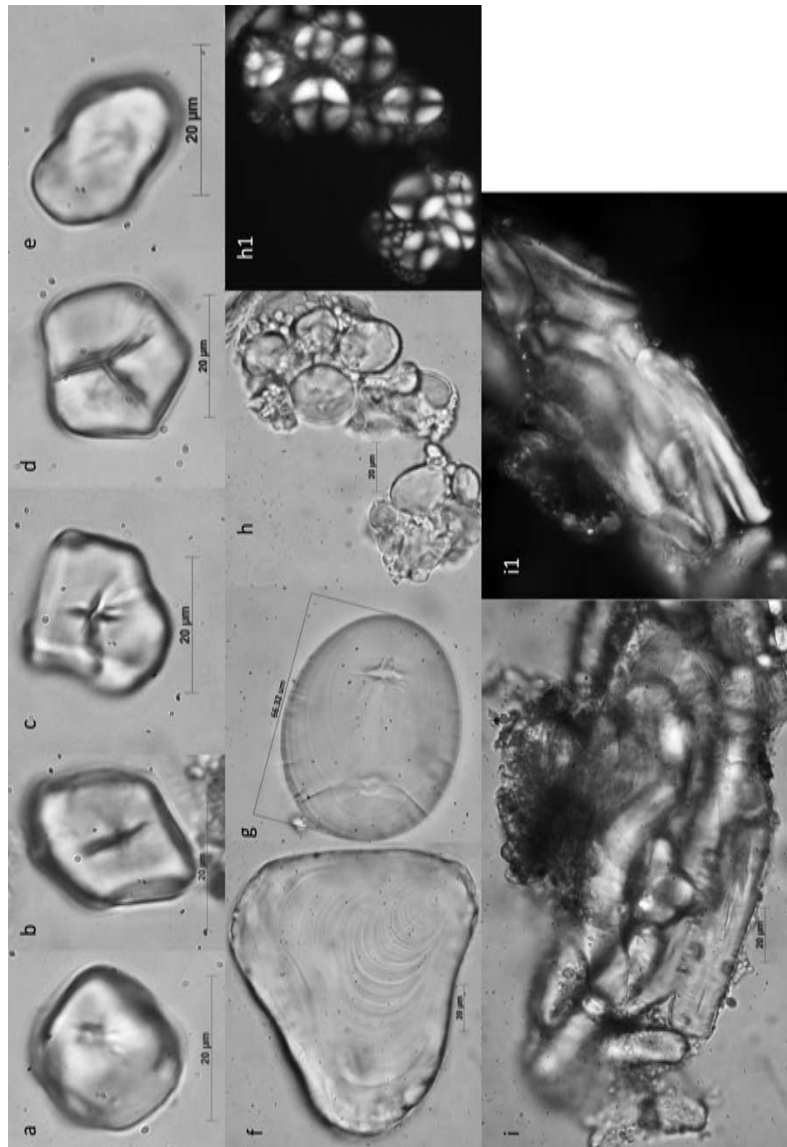


Figure 3.3 Selected starch grains of domestic and wild plants recovered from lithic artifacts at Plum Piece (Saba). *a-d*, maize (*Zea mays*); *e*, annatto (cf. *Bixa orellana*); *f*, wild yam (cf. Dioscoreaceae); *g*, wild ginger (cf. Zingiberaceae); *h-h1* (bright and dark field with polarisation, respectively), wild legume (Leguminosae-Fabaceae); *i-i1* (bright and dark field with polarisation, respectively), bijao or mardi grass (*Renanthera* spp.). Graphic scales are in μm . (Image by J. Pagán Jiménez).

circum-Caribbean island landscape and indigenous biotope (Hoogland and Hofman 2015; Keegan 1994; Newsom 1993; Pantel 1997; Rivera-Collazo 2011; Rodríguez López 1997, 1999; Rodríguez Ramos 2002a, 2002b; Rodríguez Ramos et al. 2008, 2013; Ulloa Hung and Valcárcel Rojas 2002). The Archaic Age in the northwestern region of the Greater Antilles is represented by the so-called Casimiroid peoples in Cuba and Hispaniola. They are believed to have migrated from Belize sometime around the seventh millennium BP (Callaghan 1990; Rouse 1992; Wilson et al. 1998), based on similarities in the lithic toolkits. However, despite certain resemblances in manufacturing technology with northern Central America, many aspects of the Belizean assemblages are not found in Puerto Rico or Hispaniola, the easternmost areas to which this tradition was supposed to have extended. Rodríguez Ramos and Pagán Jiménez (2006) therefore postulated an Isthmo-Colombian origin for the Puerto Rican Archaic Age assemblages on the basis of resemblances in stone tools and the use of a similar suite of food plants, such as sweet potato, bean, maize, manioc, wild yam, marunguey, archira and jack beans. The edge-ground cobble/milling stone complex was used in Puerto Rico and in south Central America to transform these plants into foods.

Similarities between some of the lithic materials found in the Greater and Lesser Antilles have drawn the attention of various scholars (Davis 1974; Febles Dueñas 1991). As such, it was argued that the technology of the blade stone industry of the Jolly Beach complex on Antigua and its related artefacts is generally far more similar to that found at the contemporary sites of Barrera-Mordán and Cayo Redondo in the Greater Antilles (Davis 2000: 99) than to the Ortoiroid artefacts. Similarly, shell vessels found at Whitehead's Bluff on Anguilla are correlated with the Casimiroid complex (Crock et al. 1995). At this point few reliable comparative data are available from both areas to draw firm conclusions about a common origin, their relatedness and inter-regional interaction patterns (see Davis 2000). However, this underlines the possibility that the origin, lifeways and human-environment interactions of the Archaic Age peoples in the circum-Caribbean in general and the northeastern Caribbean in particular may have been much more complex and diverse than was previously thought.

The Archaic Age occupants of the Lesser Antilles have always been regarded as fishers and foragers, living semi-permanently in mostly coastal settlements (Boomert 2000; Davis 2000; Keegan 1994). Sites such as for example Plum Piece, Saba, Capesterre, Basse-Terre, Guadeloupe and Upper Blake's, Montserrat show that the Archaic Age peoples also occupied the interiors and forests of these islands and fully exploited their environment. Many of the Archaic Age sites represent multiple stages of occupation, abandonment and reoccupation over long periods of time. The toolkit of the Archaic Age sites is very diverse and special activity campsites seem to have alternated with each other, producing a very dynamic social landscape in which various resources were targeted and different activities alternated in

a yearly mobility cycle (Bonnissent 2013; Hofman et al. 2006; Hofman and Hoogland 2011). It is feasible to hypothesise a form of mobility strategy for exploiting archipelagic resources in which communities would have taken advantage of the seasonality of biotic resources across the islands (Hofman et al. 2006) in combination with other cultivated food plants.

The presence of rather permanent settlements with dense midden deposits and the recent data on plant management and the dispersal of cultivated food plants, combined with the early evidence of pottery making, and the manufacture and use of the edge-ground cobble/milling stone toolkit in the Archaic Age of Puerto Rico and the rest of the Greater Antilles, point to socio-cultural developments and a (semi-)sedentary lifestyle that greatly differ from what has been widely accepted in Caribbean archaeology (Rivera-Collazo 2011; Rodríguez Ramos and Pagán Jiménez 2006). The intriguing fact that pottery was already manufactured in the islands well before the appearance of Huecoid and Saladoid ceramics, dramatically changes our views on the Saladoid colonisation process (Keegan and Rodríguez Ramos 2004; Newsom 1993; Newsom and Wing 2004: 30; Pantel 1997; Rodríguez López 1997, 1999; Rodríguez Ramos 2002a, 2002b; Ulloa Hung 2005; Ulloa Hung and Valcárcel Rojas 2002).

Early Ceramic Age settlements in the Lesser Antilles were first believed to be located predominantly on the north and east sides of the volcanic islands (cf. Haviser 1997), back from the coast, near rivers or surrounded by forest. However, it is now obvious that a variety of environments were used for habitation, including beaches near mangrove areas and reefs. Next to ongoing subsistence strategies such as fishing and collecting, intensive cultivation and processing of a variety of root and seed crops are evidenced by the widespread distribution of processing tools (e.g. scrapers, pounding/milling stones), clay griddles and cooking vessels, (e.g. Rodríguez Suárez and Pagán Jiménez 2008; Pagán Jiménez 2013). These early cultivation practices were likely later modified through the inter-cultural interactions that took place between the various peoples of the Caribbean archipelago (Mickleburgh and Pagán Jiménez 2012).

Concluding remarks

The peopling of the insular Caribbean would have initially involved exploratory expeditions from various parts of continental America instigated by a range of environmental, socio-political, economic and ideological motives. Human mobility, and the exchange of goods, ideas and information increased over millennia of pre-colonial occupation of the region (Hofman and Bright 2010; Hofman et al. 2011; Rodríguez Ramos 2010; Rodríguez Ramos and Pagán Jiménez 2006). Such processes would have favoured 'symbiotic relationships' between Archaic and Ceramic Age communities and subsequently among Ceramic Age peoples throughout the region (Hofman et al.

2007). Until recently, the idea of unilineal movements from northeastern South America into the Caribbean chain of islands has been at the foreground of scholarly thought. However, it is now also accepted that Ceramic Age communities eventually directly crossed from the mainland to Puerto Rico and the northern Lesser Antilles, bypassing the Windward Islands. This would explain the sudden appearance of Huecoid and Saladoid sites in the northern end of the chain, and the hitherto absence of such sites in the Windward Islands (Callaghan 1995; Fitzpatrick 2013; Keegan 2009; Rodríguez Ramos 2007; Rouse 1992). Another alternative may have been that the occurrence of Archaic Age tools and technologies in Huecoid assemblages are the reflection of in situ developments as a result of the inter-cultural dynamics between the Archaic Age islanders and the inhabitants of the mainland (Rodríguez Ramos and Pagán Jiménez 2006).

The recent evidence for phytocultural traditions in the islands, including humanly induced fires, the early introduction and production of crops from the mainland, and the relatively rapid dispersal and management of endogenous plants across the islands, clearly provides support to the idea that the ‘Neolithisation’ or ‘Neolithic revolution’ of the insular Caribbean was not an abrupt event introduced by the bearers of the Saladoid culture, but rather a progressive evolution across space and time. This accords well with the ongoing re-evaluation of the so-called ‘Mesolithic-Neolithic’, the Archaic-Ceramic Age or the Hunter/Gatherer-Farmer transition in other parts of the Americas and worldwide.

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4 Straddling the subsistence divide

The case of Canímar Abajo
and contemporaneous sites in
Northwestern Cuba

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Introduction

Recently recovered evidence from northwestern Cuba requires a reconsideration of subsistence regimes practiced by communities living on the island during the first two millennia BCE and the first millennium CE. In particular, we need to rethink the role of domesticated plant species, whether indigenous or exotic. The traditional view of Cuban archaeologists and, until recently, many archaeologists working in other regions in the Caribbean, was that subsistence practices during what is termed the Late Archaic were characterized primarily by resource extraction focused on exploitation of marine resources, wild plants and limited use of wild animals. Our new evidence strongly suggests that subsistence practices in Cuba were much more complex. Specifically, analysis of starch grains recovered from human dental calculus, coupled with stable isotope analysis of, and AMS radiocarbon dates from, human bone collagen indicates that cultivation of exotic domesticated plant species (common bean and, perhaps, maize) was practiced in certain ecological niches by as early as 1200 BCE, whereas resource extraction continued to be the basis of subsistence in other niches.

In this chapter, we will summarize the evidence upon which the inferences outlined above are made and discuss the implications for Cuban archaeology and the Caribbean region more generally. A detailed review of this evidence is beyond the purview of this chapter, but is presented in other publications: Buhay et al. (2013), Chinique de Armas and Rodríguez Suárez (2012), Chinique de Armas et al. (2015, 2016), Roksandic et al. (2015a), and Smith (2016).

Theoretically, our study is informed by the concepts of low-level food production (Smith 2001, 2005) and ecological niche construction (Crawford 2014; Odling-Smee et al. 2003; Smith 2007, 2009, 2011a, 2011b; Zeder

and Smith 2009). The concept of low-level food production was introduced to archaeology by Smith (2001) specifically to label those communities that occupied the ‘middle ground’ between resource extractors and full-scale resource producers. Its applicability in tropical environments such as the Caribbean archipelago is discussed elsewhere in a publication by the lead author (Smith 2016). There, it is noted that Bruce Smith did not view low-level food production simply as a stage in a unilineal trajectory automatically leading to ‘mid-’ and ‘high-level’ food production. In fact, adoption of low-level food production (however it occurred) and intensification of food production to the point of dependence (‘high-level food production’ or agriculture) should be treated as two separate processes that may or may not directly relate to each other. A community that adopts low-level food production to supplement food foraging may remain in a state of relative economic stability for some considerable time. We will argue below that our evidence suggests this occurred during the late Archaic in northwest Cuba.

Although it may be relatively steady, it is unlikely that the stability of a subsistence regime identified as ‘low-level food production’ would be absolute. It is likely to encompass a wide range of practices and commitment to domesticated resources that will vary over space and through time. For this reason, we need to sub-divide ‘low-level food production’ into finer gradations that apply to the context of the late Archaic in northwestern Cuba. In this chapter, we will use the terms ‘fisher-forager-cultivators’ and ‘fisher-cultivator-foragers’ to distinguish between what we argue are different levels of commitment to crop cultivation (see also Smith 2016).

Niche construction is a biological concept, the application of which in archaeology is relatively new, but it is, in fact, a somewhat more rigorous treatment of established approaches that incorporate landscape management (e.g., Keegan 1986), and anthropogenesis (e.g., Crawford 1997). In Caribbean research, the work of Veloz Maggiolo (1976) offers parallels to niche construction. All biological organisms engage in niche construction in their interactions with the physical environment, and humanity is no exception. The concern is to develop models that elaborate the unique ways that humans engage in niche construction. As a point of clarification, however, we are not sympathetic to models, such as that recently proposed by Creanza et al. (2012), or arguments such as those made by Gremillion et al. (2014), that attempt to tie human niche construction to Darwinian precepts. Smith and Zeder have also made clear their discomfort with human behavioral ecology theory (Smith 2011b, 2015; Zeder and Smith 2009: 682). The key to human culture is that it is communicated, not inherited biologically. Consequently, we need to develop an approach to niche construction that is uniquely anthropological. Zeder and Smith have made a limited start toward this in their attempt to incorporate what they term ‘agency’ into their formulations (Zeder 2009; Zeder and Smith 2009). They have not, however, explored the rich literature on social agency and practice theory in

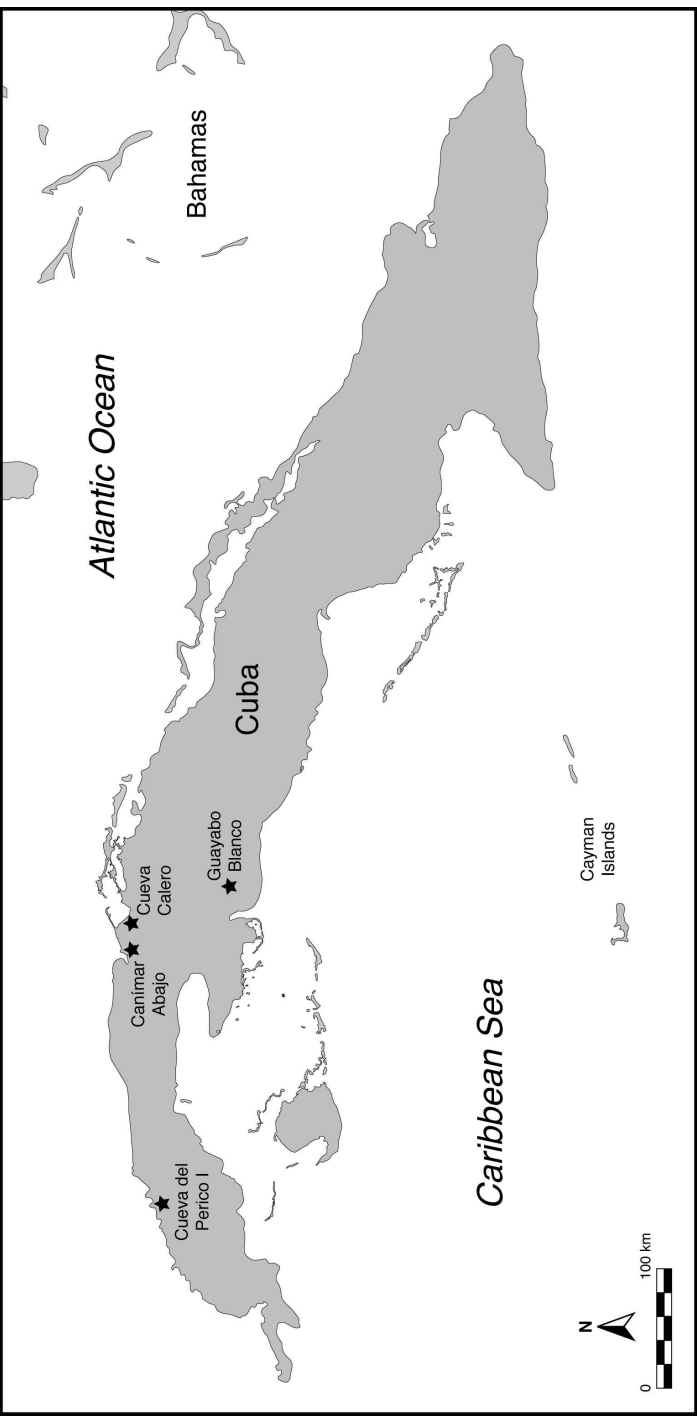


Figure 4.1 Map of Cuba showing the location of sites (mentioned in the text). (Produced by D. G. Smith).

archaeology that has emerged over the past 20 years (e.g., Dornan 2002; Overholtzer 2015; see also Bruno 2009).

Canímar Abajo

The site of Canímar Abajo is located in the Rio Canímar estuary area on the northern coast of Cuba (see Figure 4.1). Canímar Abajo has been subject to systematic excavation since 1984. The stratigraphy of the area of the site that has been excavated reveals two distinct cemeteries separated by a layer of shell midden deposits; the depth of the overall stratigraphy is roughly 2 m (see Roksandic et al. 2015a; Figure 4.2). The lower mortuary context is designated the Older Cemetery (OC) and the upper the Younger Cemetery (YC). To date, 142 burials have been excavated, 50 in the OC and 92 in the YC, yielding a total of 213 individuals (83 adults and 130 sub-adults). The predominance of sub-adults is puzzling, but it provides a remarkable sample of individuals from this age grade that can be analyzed in the future for evidence of such things as differences in pre-weaning and post-weaning diet.

No direct evidence of habitation has been recovered from Canímar Abajo to date, although the area of the site that has been excavated is relatively limited. The tool assemblage recovered from Canímar Abajo includes chipped lithics, milling stones, and shell tools. No ceramic artifacts were recovered, which led to the site being initially classed as *preagroalfarero* (pre-farmer-potter) in the Cuban system of cultural classification (Tabío 1991). Rodríguez Suárez examined the surfaces of the milling stones for starch and recovered granules from two tools, one from the OC and one from the shell midden deposits that separate the OC from the YC. The OC milling stone yielded granules identified as maize (*Zea mays*), sweet potato (*Ipomoea batatas*), marunguey (*Zamia* sp.), and beach bean (*Canavalia* sp.). The stone recovered from the shell midden deposits yielded starch grains identified as maize, common bean (*Phaseolus* sp.), cocoyam (*Xanthosoma* sp.), and yam (*Dioscorea* sp.). The identification of the non-indigenous domesticated crop species (maize and sweet potato) brought into question the classification of the site as *preagroalfarero* (Rodríguez Suárez 2007). The results of more recent analysis of starch are presented later. Molluscan shell and fish bones were the most common faunal elements recovered from Canímar Abajo. The most common mammalian elements are from the hutia (*Capromys* sp.).

Eight conventional radiocarbon dates assayed on charcoal and marine shell collected from the site between 1984 and 2010 are available. Four of these correspond with the stratigraphy and the AMS chronology outlined later. Three of the conventional dates, all on material from the OC, are older than the AMS dates and may document an earlier, yet unrecognized occupation. The last conventional date, assayed on charcoal recovered from the YC, is an outlier. At 5480–5380 cal. BCE, it has been cited as one

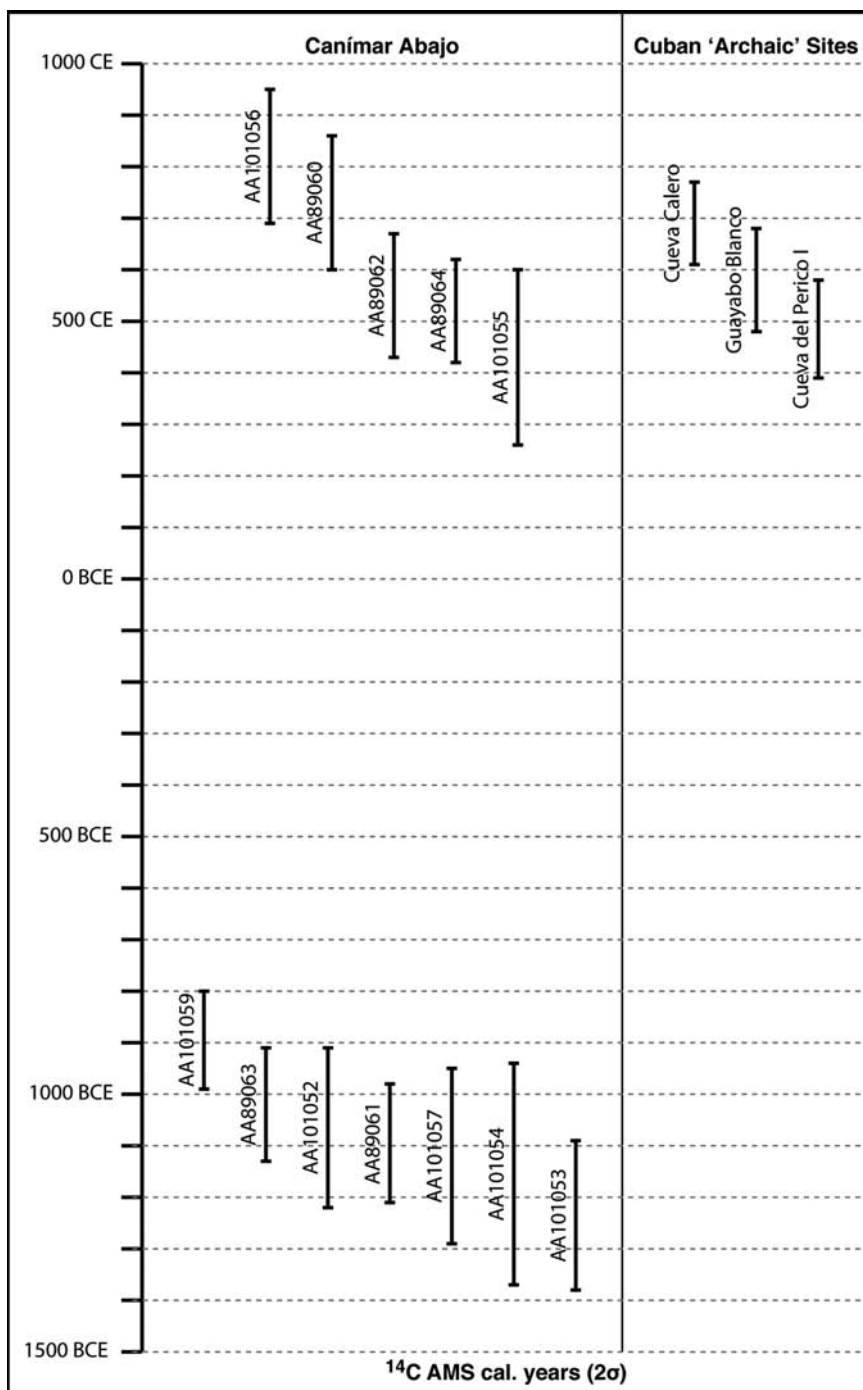


Figure 4.2 AMS radiocarbon dates from Canimar Abajo, Guayabo Blanco, Cueva del Perico I, and Cueva Calero. (Produced by D. G. Smith).

of the oldest radiocarbon dates yet reported in the Caribbean (see Cooper 2010). Because the charcoal that yielded this date is out of stratigraphic sequence, it must be regarded with suspicion until corroborative evidence becomes available.

After 2010, bone collagen extracted from nine OC individuals and five YC individuals was submitted for AMS radiocarbon determination; one further AMS date was assayed on charcoal from the OC in direct association with AMS dated skeletal remains. The methods applied to these assays are discussed in detail in Roksandic et al. (2015a). These assays yielded 11 reliable AMS radiocarbon dates; the dates are plotted at a 2σ confidence level on the left side of Figure 4.2. These dates afford a secure chronology of between 1380 and 800 BCE for the OC and between 360 and 950 CE for the YC. The stratigraphy and AMS dates from Canímar Abajo provide one of the most securely dated cultural (mortuary) contexts for this time period in the Caribbean region.

Questions of contamination have been raised about starch identified on the surfaces of tools. To mitigate such concerns, we examined human dental calculus, which provides a sealed context, for starch grains. Dental calculus was recovered from the teeth of ten individuals interred at Canímar Abajo and examined for the presence of starch granules (see Chinique de Armas 2015 for details of materials, methods and results). Seventy-nine identifiable starch granules were isolated in the calculus of 6 individuals, 66 granules from 3 individuals in the OC, and 13 granules from 3 individuals in the YC. Four types of starch were identified: 71 oval starch granules consistent with Fabaceae (beans and legumes), 3 faceted granules consistent with either maize and/or sweet potato, 4 round granules consistent with marunguey, and 1 elongate, hyper-eccentric granule consistent with an underground storage organ such as that of the Marantaceae family (arrowroot). Of these, by far the most common, and the most definitive by occurrence, are those consistent with Fabaceae: of the 71 granules, 58 occurred in two clusters of 36 and 22 measurable grains, each from separate individuals. These 58 granules are consistent with common bean (*Phaseolus vulgaris*), a cultivated crop species that is not native to the Caribbean archipelago. From these results, we can make a strong argument that the people of the Canímar Abajo OC were cultivating and consuming common beans by as early as 1200 BCE. Seven starch granules consistent with Fabaceae were recovered from individuals buried in the YC, three of which are consistent with common bean, indicating that the cultivation of common beans likely continued to be a part of the subsistence regime in the Canímar estuary locale well into the first millennium CE. Because marunguey is native to Cuba, has a long history of consumption in the Caribbean (Keegan 1994; Newsom 1993), and has been reported in early archaeological contexts elsewhere (Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez et al. 2015), its identification is not problematic. The numbers of starch granules identified in the other two types are too low to support definitive claims for the

exploitation of maize/sweet potato and arrowroot based on starch analysis, but the stable isotope analysis (see later) indicates that a C_4 plant, such as maize, was consumed.

Bone collagen extracted from both OC and YC individuals was subjected to stable carbon and nitrogen isotope analysis to obtain evidence for dietary protein sources and to provide a signature that could be compared to other sites (see Buhay et al. 2013 and Chinique de Armas et al. 2015 for a detailed discussion of materials, methods, and outcomes). The results indicate that the people of Canímar Abajo consumed a diet of marine animals (fish and mollusks), terrestrial mammals (e.g., hutia), and limited but significant amounts of C_3 and C_4 plants. The stable carbon and nitrogen isotope signatures from both the OC and YC are very similar, indicating continuity of dietary preferences between the two cemeteries.

The common bean and marunguey identified in the starch analysis would contribute to the C_3 component of the plants consumed. Maize is the most commonly identified plant that would contribute to the C_4 component and has been widely reported at other sites throughout the Greater Caribbean. Of particular note is the identification of maize starch on five grinding implements recovered from the site of St. John, on the island of Trinidad, associated with AMS radiocarbon dates in the range 7790–7670 cal. BCE (Pagán Jiménez et al. 2015). Thus, maize was present in the insular Caribbean region at least 4,000 years before our earliest date from the Canímar Abajo OC and likely was available to the people of the Canímar estuary. We are of the opinion that maize most likely contributed the C_4 component of the plants consumed, but confirmation will require further research.

In sum, our current stratigraphic and chronometric evidence from the site of Canímar Abajo indicates that the area excavated was used as a burial ground in two stages, the first between 1380 and 800 BCE (580 years), and the second between 360 and 950 CE (590 years). These are minimal estimates only, and we attach no significance to the similarity in estimated periods for the OC and YC. We do not know the full extent of cultural deposits at Canímar Abajo, neither do we know how much of the site was destroyed by the construction of campground buildings. We can say, however, that the portion of Canímar Abajo that has been excavated is quite limited. We do not know if the stratigraphic profile revealed to date (two mortuary contexts separated by a shell midden) characterizes the rest of the deposits at the site. It is also possible that the specific area of the site used as a burial ground shifted over hundreds of years.

Guayabo Blanco, Cueva del Perico I, and Cueva Calero

The burial sites of Guayabo Blanco, Cueva del Perico I, and Cueva Calero are located in western Cuba in upland areas outside major river valleys or estuaries (see Figure 4.1). These sites were classed as affiliated with the

Guayabo Blanco culture of the Archaic Age, according to the general Caribbean cultural classification formulated by Rouse (1992) and *preagroalfarero* according to the Cuban system. The chronology of these sites is controversial. They have been attributed to both the earliest settlers on the island and the last vestiges of the Guanahatebey in western Cuba at the time of European contact. Three conventional radiocarbon assays on charcoal from one of the sites (Cueva del Perico I) returned dates between 100 BCE and 800 CE (Cooper 2010: 95).

One assay of human bone collagen from each site was submitted for AMS radiocarbon dating. The dates returned are plotted on the right side of Figure 4.2 and fall between 390 and 770 cal. CE (2 σ), generally confirming the conventional dates returned from Cueva del Perico I. We recognize that a limited sample of four radiocarbon assays (three AMS and one conventional) is inadequate to establish a secure chronology for these sites. It is unlikely, however, that all four of the radiocarbon dates from these sites would be rejected with more assays. We can argue with some confidence that Guayabo Blanco, Cueva del Perico I, and Cueva Calero were roughly contemporaneous with the Canímar Abajo YC.

For purposes of comparison to Canímar Abajo and other sites in the Caribbean archipelago, samples of human bone collagen were extracted from a total of 29 individuals: 6 from Guayabo Blanco, 11 from Cueva del Perico I, and 12 from Cueva Calero. These samples were subjected to stable carbon and nitrogen isotope analyses, employing the same methods as those from Canímar Abajo. The results of the stable isotope analysis are reported in Chinique de Armas et al. (2016). To summarize, the dietary protein signatures of Guayabo Blanco, Cueva del Perico I, and Cueva Calero are similar to each other, but different from both the OC and YC at Canímar Abajo.

Comparison of isotopic signatures to other sites in the Greater Antilles

To broaden the base of comparison for the results of the stable carbon and nitrogen isotopic analyses, isotopic signatures were compiled for other sites in the Greater Antilles and Bahamas. These include Tutu on St. Thomas in the US Virgin Islands, Río Tanamá, Punta Candelero, Tibes, Paso del Indio, and Maisabel in Puerto Rico, and a composite set of values from sites in the Bahamas (see Chinique de Armas et al. 2016). On the basis of radiocarbon assays, all of these sites date to after 1 CE, and are considered of Saladoid/Ostionoid age. All are identified in the literature as agricultural; that is, they have yielded evidence of full-scale food production. The isotopic signatures from these extra-Cuban sites are all generally similar to each other, and much more similar to the values from Canímar Abajo (both the OC and YC) than to those from Guayabo Blanco, Cueva del Perico I, and Cueva Calero.

Discussion

Our current evidence, based on AMS radiocarbon dates, stable isotope analysis, and starch analysis, indicates that the Canímar community or communities constructed an ecological niche in the Canímar estuary locale that was significantly different than the niche occupied by other communities in western Cuba. Their subsistence niche entailed a combination of exploitation of marine resources, gathering wild plants, hunting/trapping terrestrial animals (especially the hutia), and low-level food production in the form of crop cultivation. They maintained a relatively stable suite of subsistence practices for hundreds, if not thousands, of years.

Communities of fisher-foragers represented by the sites of Guayabo Blanco, Cueva del Perico I, and Cueva Calero surrounded the Canímar estuary community or communities. Because of a lack of data, our inferences concerning the nature of the ecological niche construction engaged in by the Guayabo Blanco, Cueva del Perico I, and Cueva Calero communities are much more constrained. These other communities, however, can be seen as occupying a different ecological niche than the people in the Canímar estuary. As far as we can tell, the groups who used the four sites as cemeteries did not engage in the practice of crop cultivation.

A number of hypotheses can be proposed concerning the origins of the Canímar estuary community or communities and their particular ecological niche. First, they may have resided in the Canímar estuary locale for an extended period of time, prior to adding crop cultivation to an existing fisher-forager subsistence regime. If this was the case, it is likely that they transitioned from fisher-foragers to fisher-forager-cultivators, and then to fisher-cultivator-foragers. Second, they may have resided elsewhere in Cuba and moved to the Canímar estuary locale upon adopting crop cultivation. Third, they may have moved to the Canímar estuary locale from elsewhere in the Caribbean. Fourth, they may have migrated from somewhere on the mainland areas of the circum-Caribbean region, bringing crop cultivation with them. Fifth, their origins could have consisted of a combination of any or all of the above. None of these hypotheses can be confirmed or eliminated on the basis of our current data. The current resolution in DNA analysis does not allow us to pinpoint any area of the mainland that may have been the biological source for migrants to Cuba or anywhere else in the Caribbean. The domesticated crop species that we have identified (or provisionally identified) provide some guidance in a general fashion, but nothing specific. For example, common beans and maize are generally recognized as being domesticated in Mexico, but their vectors and rates of diffusion from their source(s) are controversial. Furthermore, dental modifications identified in at least seven individuals, three from the OC and four from the YC (Alarie and Roksandic 2016; Roksandic et al. 2016), do not conform to the styles of modifications practiced in Mesoamerica. Rather, they consist of chipping and filing upper incisors into an inverted 'V,' a style encountered among

certain Arawakan (Farabee 1918) as well as Chibchan groups (Stewart 1942). Linguistic analysis of Western Cuban toponyms, based on their morphophonological characteristics, also indicates a possibility that early Cuban populations might have migrated from Lower Central America / Isthmo-Colombian region (Roksandic 2013).

Although much further research will need to be conducted to confirm (or disconfirm) these inferences, we may make some observations about the nature of niche construction in western Cuba using the concepts of localized niche and territorial niche. We argue that a community or communities of low-level food producers were engaged in the construction of a bounded and localized niche in the estuary region of Rio Canímar during at least the first two millennia BCE, if not before and after. With less confidence, we can suggest that the Guayabo Blanco, Cueva del Perico I, and Cueva Calero sites were used by communities that occupied a territorial niche that was much less bounded and constrained.

Issues of community mobility are raised by the differences in cultural niches. There is a rich ‘middle ground’ between highly mobile settlement strategies and full sedentism. This ‘middle-ground’ has been explored to some extent by other researchers, employing the concepts of fixed-point mobility and tethering, that ultimately are grounded in Flannery’s proposals about seasonal scheduling (Flannery 1968). Ingold (1983), for example, used the term ‘fixed-point nomadism’ to refer to communities whose settlement-subsistence strategy involved a seasonally scheduled return to one particular location (or fixed-point) that was attractive for any number of reasons. The idea that communities may become ‘tethered’ to a locale can be traced to Taylor (1964). It was explored in more detail from a processual perspective by Binford (1980), although he ignored the ideational status of certain fixed-points that may also have ‘tethered’ communities to a specific locale. More recently, Bruce Smith argued that niche construction tethers communities to certain locations (Smith 2011a). Whether the Canímar community or communities were tethered to the Canímar estuary locale for economic reasons, or whether the Canímar Abajo cemetery was an ideational fixed-point for a community that incorporated some degree of mobility into its settlement regime, or both, cannot be ascertained with our current body of evidence. As noted earlier, although there are shell midden deposits at Canímar Abajo, no direct evidence of settlement has been recovered in the area of the site that has been excavated to date. In addition, there are no nearby habitation sites that can be linked to Canímar Abajo with any degree of confidence, although the site of Playita, located about a kilometer upriver from Canímar Abajo, yielded lithic material similar to that from Canímar Abajo (U. Herrera, personal communication, 2015).

In any scenario, the commitment of the Canímar estuary community (or communities) to a particular locale to bury their dead is noteworthy. Support for continuity of dietary preference between the OC and YC is supplied by the similarity in stable isotope signature, and for cultural

continuity by the occurrence of a unique form of purposeful dental modifications. The ideational commitment of the Canímar estuary community to Canímar Abajo as a burial site raises issues of social memory that are discussed by Hodder and Cessford (2004), Mills (2010), and Peterson (2013). Social memory is linked specifically to mortuary practices by the chapters in Chesson (2001) and by Wilson (2010). Archaeologists from Leiden University in the Netherlands are applying the social network approach in the Caribbean region (e.g., Mol 2013; Mol and Mans 2013). Social network analysis explores social interaction among groups of people by applying network and graph theory, thereby enabling relationships to be illustrated graphically. The concept of communities of practice, such as applied in Europe by Kohring (2011, 2013), could be fruitfully applied once the body of information derived from the region reaches critical mass. A community of practice is a group of people who are linked by sharing a common experience, such as niche construction and/or burial of the dead, through time (see Mills 2016).

Conclusion

Our research on the island of Cuba supports the contention, made by Pagán Jiménez (2011, 2012, 2013) and Rodríguez Ramos et al. (2013), among others, that the introduction of crop cultivation and the emergence of resource production in the Caribbean are much more complex than previously envisioned (see also Smith 2016). Multiple lines of evidence enable us to confidently state that, by ca. 1200 BCE, low-level food producers inhabited the Rio Canímar estuary locale. We cannot claim that we have documented the earliest introduction of crop cultivation and/or exotic domesticated plants to Cuba or the Caribbean. It is likely that the low-level food producers of the Canímar estuary were there for hundreds, if not thousands, of years. In fact, the evidence from Trinidad (Pagán Jiménez et al. 2015) indicates that domesticated species could have made their way into the Greater Antilles long before 1200 BCE. Our research demonstrates that evidence for low-level food production may be difficult to recognize using traditional archaeological approaches. Indeed, it is possible, if not probable, that low-level food production was widespread, not simply in the Caribbean region, but worldwide, and we are only now beginning to recognize it.

In this chapter we have used the concepts of ecological niche construction and low-level food production to explore the nature of settlement-subsistence regimes in ancient western Cuba. Present evidence suggests that the Canímar estuary low-level food producers had constructed a unique subsistence niche in this locale, one that was not shared by their immediate neighbors. Why this was the case is a crucial question that we cannot resolve with our present data. To pursue this question, we will have to gather much more empirical data, but we also need to expand our theoretical palette.

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5 Early horticulturalists of the southern Caribbean

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Introduction

The islands of the southern Caribbean and the adjacent coastal fringe of mainland Venezuela encompass a great variety of landscapes united by a relatively homogeneous geomorphology, physiography, climatic regime, biodiversity, and the presence of anthropic areas that remain minimally disturbed. These characteristics make this macroregion an appropriate setting to gauge deep-in-time paleoclimatic and paleoecological changes, and to study their interrelations within the context of long-term sociocultural and political-economic trajectories.¹ In historical-cultural and cultural-ecological approaches, this macroregion has been portrayed as the crossroads of people, goods, and ideas between Amazonia, the Andes, and the insular Caribbean (Osgood and Howard 1943; Rouse and Cruxent 1963; Spinden 1916; Steward 1948; Wagner 1978; Willey 1960).

During the last decades, with the development of the deep-time perspectives of human ecodynamics and multidimensional approaches to biocultural evolution, research has become increasingly interdisciplinary. These approaches have also been informed by the realization that humans are not passive adaptors to their environment, but are rather creatively shaping it as a socio-natural landscape moulded through complex and dynamic biological, sociocultural, and environmental feedbacks (Baleé 2010; Barton et al. 2011; Borrero 2015; Denevan 2001; Erickson 2003; Kirch 2007; Oliver 2008). Concomitantly with these broader theoretical shifts, aided as they are by increasingly sophisticated field and laboratory tools and techniques, the approaches to the origin of or transition to agriculture have also been substantially transformed (Langlie et al. 2014). As a result, ‘agriculture’² has been freed from the dependency on environmental determinism and decoupled from domestication and the production of pottery, while mixed economies have been increasingly considered instead of full agricultural intensification (Erickson 2008; Greaves and Kramer 2014; Pluciennik and Zvelebil 2008). Importantly enough, social complexity in its varied forms, as well as mobility, exchange, and communication have been (re)introduced into the Caribbean Archaic Age (e.g. Curet 2003; Hofman et al. 2006;

Keegan 2004; Ulloa Hung and Valcárcel-Rojas 2013), challenging the persistent remnants of 19th-century progressive and unilineal cultural-evolution that attributed these characteristics only to Neolithic (or Caribbean Ceramic Age) societies. Thus, the research has been ‘softened’ or even radically changed by the denial of any clear-cut distinction between foragers’ and farmers’ modes of living and worldviews, and by incorporating perspectival and post-humanist ontologies into research agendas (Barker 2009; Terrell and Hart 2008; see also Grøn and Kuznetsov 2004). All in all, the origin or spread of horticulture or agriculture is no more perceived as a single-cause process but as a result of a confluence of environmental, socioeconomic, and ideological processes (Pluciennik and Zvevibel 2008: 471).

In this chapter, we discuss the current knowledge of the causes, dynamics, and timing of the processes involved in the transition from the Archaic Age gatherer-fisher-hunter economies to horticulture-based farming in the southern Caribbean.³ We begin with the geo-environmental presentation of this study region, followed by a brief overview of its earliest signatures of human presence. The chapter will subsequently focus on selected case studies that explore the different processes of transition to horticulture in the region of interest. It will conclude by briefly discussing some avenues for future research.

Geo-environmental contexts of the southern Caribbean in the Archaic Age

To fully understand the human experience in the southern Caribbean, we must first envision the geographic and environmental contexts of the region, as a distinctive area within the broader insular and circum-Caribbean macroregion (see Figure 5.1).

The geological contexts of the southern Caribbean indicate a primary emphasis on the tectonic abrasion between the Caribbean and South American plates as the major factor for significant geologic events, rather than more recent volcanic activity that is characteristic of the eastern Caribbean. From Curaçao to Los Testigos, this island chain is separated from the (now Venezuelan) mainland by the Bonaire Trench with a depth of over 1000 meters (Silver et al. 1975; Stock 1982). Within the southern Caribbean group of islands identified in this chapter, Aruba, Margarita, and Trinidad are not separated from the South American shelf; they became continental islands due to the post-Pleistocene sea-level rise (Schubert and Moticska 1972, 1973; Schubert and Valastro 1976).⁴ To the north of this island chain, the Los Roques Trench and the Curaçao Outer Ridge isolate the islands from the oceanic Caribbean Basin. All of these features are the result of a Late-Cretaceous frictional grinding of the southern edge of the Caribbean tectonic plate as it moved west across the South American tectonic plate, this creating a series of fault lines (Oca, Sabastian, Cuiza, etc.) along the northern South American coastline (Beets 1977). A significant consequence

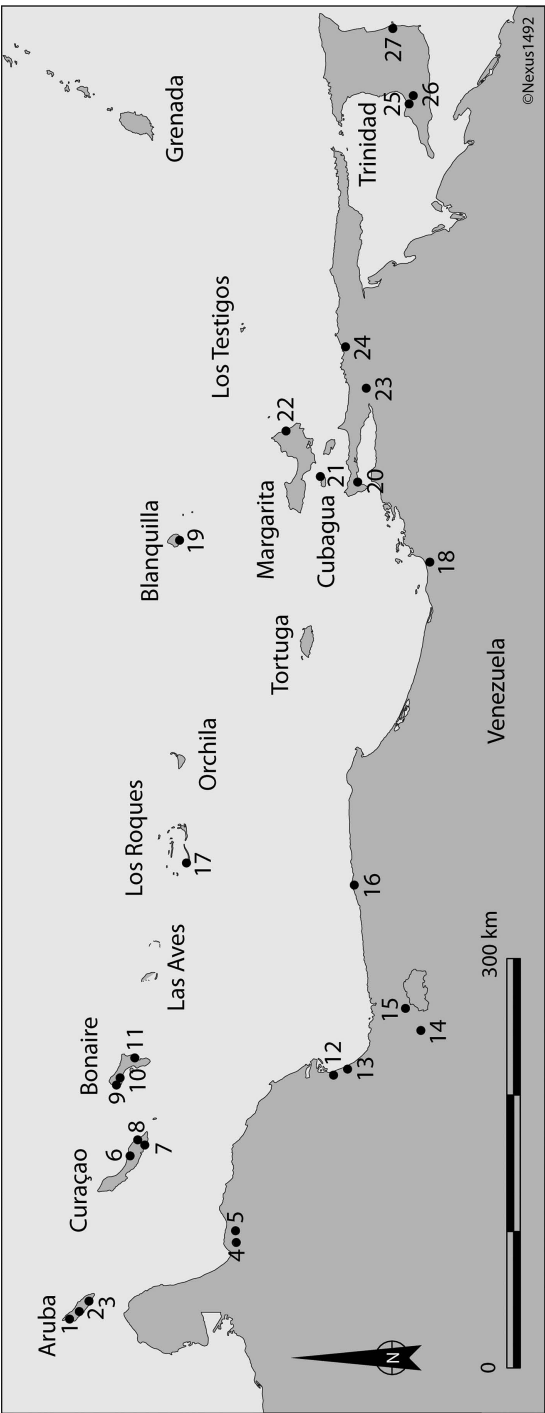


Figure 5.1 Map of the southern Caribbean region showing the archaeological sites discussed in the text. (Produced by M. Hoogland with contributions by A. Antczak).

of this unique geological context is the potential and actual presence of historical earthquakes and resulting tsunamis in the region. At least three major tsunamis are known to have occurred in this region between 3500 and 500 BP (Engel et al. 2010; Scheffers 2002; Scheffers et al. 2009).

Like many localities around the world between 10–15 degrees north of the equator, the southern Caribbean has an evaporation rate that greatly exceeds precipitation (Boovert 2000; Gallagher 1976). Thus, these islands, with the exception of Trinidad, are primarily semi-desertic environments with xerophytic vegetation (Lahey 1973; Trewartha 1961). In view of the Holocene, it becomes much more relevant to understand the paleoenvironmental conditions of the region which affected the subsistence strategies and overall lifeways of early human populations. On the basis of palynological studies across northern South America, we have been able to gain some perspectives concerning the contexts of the natural vegetation available to the Archaic Age populations. These studies show a transition from warm and moist environments between 10000 and 5000 BP, some fluctuations to a very dry environment from about 3000 BP, to the present consisting of cactus and thorn-scrub vegetation (Rull et al. 2010; Schreve-Brinkman 1978; Sealey 2001; Van der Hammen 1978). These environmental conditions suggest that the Archaic Age peoples of the southern Caribbean had to develop certain responses to these fluctuations. One of these responses seems to have been the exploitation of the agave plant (*Agave cocui*), locally known as *magüey*, an amino acid-rich, xerophytic plant with multi-use functions, such as fibre production. In several archaeological contexts on both Curaçao and Bonaire, a specific shell tool has been associated with the shredding of the agave leaves for fibre extraction (Haviser 1987). This exclusively Archaic Age tool on Curaçao and Bonaire, has ‘nipple-tip’ use-wear on the apex of a *Lobatus gigas* columella gouge, while the tip diameter matches the space between the heavy fibres in the agave leaves (Haviser 1987). The xerophytic vegetation contexts of the region in the Archaic Age, with the exception of Trinidad, have also produced archaeological evidence that suggests that the Archaic Age population may have used other cactus and dry scrub plants (Gallagher 1976; Kidder 1944), as well as utilized mangrove estuarine resources (Haviser 1991). Other dry environment food sources in the Archaic Age, found in archaeological contexts on the islands, include: land crabs, snails, iguanas, and tortoises, and various marine shellfish, fish, and bird species associated with the mangrove niches (Haviser 1991). Mangrove estuarine and lagoonal resources formed the mainstay of the Archaic Age subsistence strategies in Trinidad, the only island largely covered with tropical forest in the southern Caribbean.

Other important paleoenvironmental factors in the region that would have affected potential Archaic Age horticultural practices, are: (1) the eustatic fluctuations of sea level, and thus of water-table levels, and (2) its location being generally outside the tract of hurricanes during the past few

millennia. Minor sea-level fluctuations have been noted in archaeological contexts across the region during the period between 5000 and 3000 BP (Cruxent and Rouse 1958; Gallagher 1976; Sanoja 1980). These coastal effects were caused by both eustatic and some isostatic movements. The results of the changing sea level also affected the size and dimensions of the inland bays on the islands of the southern Caribbean, and by extension their mangrove niche contexts. This variation of inland bay formations can be discerned in the archaeological contexts of Archaic Age site locations and artefact assemblages, as noted on Bonaire (Haviser 2001; Haviser et al. 2011). This brief overview of the southern Caribbean considers the actuation of early indigenous peoples as an inextricable part of paleo-landscapes that were not merely detached backdrops for the playing out of human lives.

The earliest human footprints

Although the first immigrants into South America would have arrived without domesticated plants, their interactions with the native biota and management of plant resources were part of their socio-cultural heritage as early as the Pleistocene-Holocene transition (Borrero 2015: 130). Bottle gourds were used as containers and possibly other plants were also managed by these early hunter-gatherers (Erickson et al. 2005; Piperno 2006). Through the routine of seasonal gathering, processing, use, and discard, through the protection of selected species and introduction of new ones, as well as through soil modification and tilling and/or burning of woodland and grassland, the plants of the new regions became accustomed to human presence. Moreover, many became dependent on anthropogenic environments and entrapped within a web of often mutually beneficial relationships (Hodder 2012; Pluciennik and Zvelebil 2008: 470). Thus, in order to grasp the diachronic pulse of the growing entanglement between humans and plants, it is essential to consider deep-in-time beginnings of such interactions.

Paleontological remains, without associated proof of human presence, have been recovered across the entire mainland Venezuelan coastal zone facing the southern Caribbean islands, from the piedmont of Sierra de Perijá mountains to the west (McDonald et al. 2013), through the northwestern present-day state of Falcón (Gruhn and Bryan 1984; Sánchez-Villagra et al. 2010), the centrally located Lake Valencia Basin (Carrillo et al. 2008), and towards the easternmost situated state of Monagas (Rincón et al. 2009). Such remains have also been found at six localities in southwest Trinidad (Boomert 2000: 42). Thus far, the better researched sites, in which Pleistocene faunal remains were found together with signatures of human activity, have been reported from the coastal part of the Venezuelan state of Falcón. At the site of Muaco, abundant remains of mastodon, megatherium, glyptodont, wolf, horse, and other Pleistocene animals were found associated with ancient hunter-gatherer activities (Cruxent 1961; Rouse and Cruxent 1963: 35).

Muaco was interpreted as a kill site where lithic artefacts were scarce. Large animal bones, used as anvils or chopping blocks, show traces of intentional breaking, grooving, and cutting, while some other bones were purportedly burnt. In the adjacent site of Taima-Taima, additional evidence of human activity was found (Bryan et al. 1978). Here the paleontological and archaeological evidence together permitted the reconstruction of a kill site that was situated around a waterhole existing in late Pleistocene times. This water hole attracted both megafauna and man. In 1976, the butchered remains of a juvenile mastodont in association with an El Jobo projectile point and a utilized jasper flake were found associated to vegetal matter, believed to be the stomach content of the animal. The latter was dated by radiocarbon to 14000–12500 BP (Ochsenius and Gruhn 1979). The El Jobo lithic tool kit was abundantly documented by José Maria Cruxent and his collaborators at the kill sites and lithic workshops dispersed along the Pedregal River in the north of Falcón State (Oliver and Alexander 1990; Rouse and Cruxent 1963: 27–31; see Veloz Maggiolo and Martín 1983).

Jaimes (1999) has reported additional data on Lithic Age or Paleo-Indian sites from the states of Falcón and Lara in the Venezuelan Andean piedmont region, and analysed a series of paleoenvironmental indicators for both areas. He found that the northern coastal regions might have had more arid (16000–14000 BP [Ochsenius 1980]) and the southern regions more humid Late Pleistocene-Early Holocene paleoenvironments. The radiocarbon dates of megafaunal remains from the south appeared to be younger than their above-mentioned northern counterparts: Quebrada Maraquita (10950–10450 BP), El Vano (10710±60 BP); El Palomo (7750±80 BP), Cerro El Palomo (5450 BP) (Tamers 1969), and La Fundación (6840±190 BP) (Jaimes 1999). Arguably, being less arid, the Andean piedmont could sustain the megafauna much longer than the northern coastal regions, which might have allowed a longer continuation of the mode of life of the hunter-gatherers in this area as well. The purported paleoenvironmental difference and the resulting differential availability of megafauna could have led to the adoption of different modes of life by the northern and southern Lithic Age groups. Jaimes (1999) has suggested that various bands of hunter-gatherers had to be responsible for the dispersion of the El Jobo lithic artefacts across the some 40,000 km² between Falcón and Lara states (some 370 km from north to south). However, while multifunctional sites have been found in the north, semi-specialized and specialized sites were documented in the south. This difference may be related to the disintegration of local bands resulting from internal social tensions, the pressing of other groups, and/or environmental factors. These bands apparently exploited diverse eco-niches and types of raw materials, but maintained with their northern counterparts a common techno-morphologic conceptualization of a lithic industry that was simple and flexible (Jaimes 1999: 108).

Indeed, a flexible technology would have allowed the first colonizers of the South American continent to occupy diverse environments without

marked preferences (Borrero 2015; Bryan 1973; Pearson and Bostrom 1998). However, while the hunting of mega-herbivores was a common denominator for these groups, not restricted to a specific season, the exploitation of previously unknown inlands with diverse and seasonally available plants and the hunting of small game were locally bounded subsistence strategies which required slowing down the tempo of trans-regional mobilization after the herds of megafauna. This slowing down was necessary in order to permit the accumulation of locally sensitive bio-ecological knowledge and to gain experience while occupying the paleo-landscapes. At the other end, due to the changes in sea level and concomitant climatic and bio-ecological fluctuations, coastal groups became more dependent on sea resources permitting the development of a more generalized Archaic Age mode of life along the coasts and on the islands. These local signatures suggest, according to Jaimes (1999), that the technoeconomy of the Joboid people showed generalized strategies that escape the narrow definition of an "Archaic style of life" (Dillehay et al. 1992), their consideration as hunters specialized in megafauna (being the product of rapid migration rather than slow colonization), and as bearers of an ancestral tradition evolved on the North American Plains (Haynes 1969; Martin 1973). These signatures seem to suggest that early local and regional specificities paved the way for developmental trajectories leading towards fully Archaic Age modes of life and further, probably, towards the transition to horticulture.

Thus far, artefacts representative of the transition period from the hunting of large mammals in the Late Pleistocene to hunting of modern fauna during the Early Holocene have not been recovered from unquestionable archaeological contexts on the islands of the southern Caribbean. A bifacially chipped, stemmed spearhead has been reported from Biche site on Trinidad (Boomert 2000, figs. 6, 49) and similar artefacts are known from Margarita Island (de Booy 1916, figs. 10, 22; Cesari 1995). A proximal fragment of a lanceolate spearhead, made of milky quartz, was found in a Ceramic Age context dated to AD 1200 on Cayo Sal Island, and has been interpreted as an heirloom (Antczak and Antczak 1991: 348). Similar artefacts attributed to the Canaima complex, defined for the Upper Caroní River region in Venezuelan Guayana (Cruxent 1971; Cruxent and Rouse 1956, 1958; Rouse and Cruxent 1963), have been reported from across northern Venezuela from its western (Cruxent 1962; Sanoja 1982: 173, fig. 76) and central zones (Cruxent and Zucchi 1964; Dupouy 1945) to the Upper Orinoco (Barse 1989, 1990), and Gran Sabana in the southeast (Dupouy 1957, 1960). Most likely, incipient navigational technology, skills, and knowledge precluded the Lithic and Early Archaic Age peoples from sustained visiting or colonization of the islands most distant from the Southern Caribbean continental coast.⁵

The Archaic Age sites on the southern Caribbean are typically associated with shell middens, consisting mainly of bivalves, fish bones, echinoderms, and other remains of marine animals. Bone projectile points used for fishing now largely replaced stone projectile points which were previously employed

for hunting land game (Rouse and Cruxent 1963: 40). The sea-oriented Archaic Age populations from the circum-Caribbean mainland coast developed navigational technologies, skills, and knowledge of the sea to such unprecedented levels that they were able to colonize the islands of Aruba, Curaçao, Bonaire, Margarita, Cubagua, and Trinidad, and temporarily visited the island of La Blanquilla. Before focusing on these specific islands, let us briefly examine the mainland coast of the southern Caribbean, where human societies were already forging the Archaic Age lifestyles.

On the western coast of Venezuela, the radiocarbon dates associated with Archaic Age populations begin between 5550 ± 100 and 5190 ± 120 BP at the Cerro Iguanas shell midden in the area of Tucacas. The midden site of El Heneal in the western part of the central coast is younger, dating to 3400 ± 120 BP. It is probably related to the barely known Cabo Blanco shell midden on the central coast (Rouse and Cruxent 1963: 155). To the east of the central coast, a date of 2450 ± 90 BP is associated with a series of shell middens at the Pedro García site (Rouse and Cruxent 1963: 38). On the northeastern coast and islands, three Archaic Age complexes can be distinguished: Cubagua, Manicuaire, and Punta Gorda, all of which are ascribed to the Manicuaroid series (see later).

Along the northeastern mainland coast a series of shell middens was encountered at Ño Carlos, Guayana, and Remigio (Sanoja and Vargas-Arenas 1999a: 147). The latter site yielded dates of 5270 ± 110 and 4570 ± 70 BP. However, its deepest layers may attest to an even earlier presence of Archaic Age peoples (ca. 7000–6000 BP), who exploited the mangrove areas and focused on marine resources (Sanoja and Vargas-Arenas 1999a: 149). According to Sanoja and Vargas-Arenas (1983, 1999a, 1999b; Sanoja 1982), the Archaic Age societies of northeastern Venezuela formed part of a horizon that extended from the Gulf of Paria to Trinidad and stretched along the coast of the Guianas as far as Brazil.

In southeastern Venezuela, a series of Archaic Age sites has been reported from the Caroní River region (Sanoja and Vargas-Arenas 2007: 181). Here, the earliest sites of the Caroní Tradition are dated to the Late Pleistocene and Early Holocene between 12000 and 9000 BP. The materials include robust choppers and unifacial flints made from ferrous quartzite and their bearers frequented the rapids of the river. It is followed by the Guayana Tradition (9200–7010 BP), characterized by peduncular projectile points, knives, perforators, and other artefacts made from quartz, chert, and chalcedony (Sanoja and Vargas-Arenas 2007). The Caroní Tradition was oriented towards exploitation of the local resources of the Caroní River, swamps, and gallery forests, while the hunter-gatherers of the Guayana Tradition exploited resources of the forest and interior savannas. Beyond Venezuela, the Caroní Tradition resembles the Itaparica Tradition of Mato Grosso and Monte Alegre on the Lower Amazon, while the Guayana Tradition seems related to the Umbu Tradition of southern Brazil (Sanoja and Vargas-Arenas 1999a: 119, 122).

In the area of Puerto Ayacucho in southern Venezuela, Barse (1989: 12) recovered at least three sites with evidence of 'preceramic' occupations in stratified contexts on the alluvial terraces and relict channels of the Orinoco River. These 'preceramic' components allowed the definition of an Atures Tradition for the Archaic of Orinoquia, subdivided into Atures I (9200–7000 BP), characterized by flakes and scrapers related to the tropical forest, and Atures II (7000–4000 BP), associated with projectile points and flakes used in savannas and forests emerging with the drier climate of the Middle and Late Holocene (Barse 1995: 108). Based on the site locations, technological characteristics of the lithic toolkit and chronology, the Archaic Age people of Orinoquia had a broad-spectrum economy, collecting, hunting, and fishing in the savannas and forests, and were probably grouped in bands. Barse (1995: 112) suggests that the origin of the Atures Tradition should be sought in the Archaic Age complexes of the early post-Pleistocene of the Bogotá Plateau, Colombia. The settlers from the Bogotá Plateau (7000–6000 BP) were familiar with the exploitation of lowland resources. Importantly, from a macroregional perspective, we know that the Orinoquian Archaic Age peoples maintained connections between the highlands and lowlands and exploited different ecological zones (Gassón 2002: 266). Wagner (1993: 273; 1999) reported Archaic Age occupations at the Capacho and Lomas Bajas sites in Táchira State of the Venezuelan Andes. The first site is a shell midden while the second one yielded molluscs, scrapers, and animal bones.

All the above-mentioned sites of inland Venezuela are important in understanding the trajectories of Archaic Age human interactions between the basins of the Amazon and Orinoco rivers as well as between the Andean west and Antillean north. Bearing in mind the above-outlined scenario, we proceed to discuss the presence of Archaic Age peoples on the southern Caribbean islands.

Trinidad

Entering Trinidad from the mainland about 6000 BC, the first Archaic Age Amerindians of the island settled on hillocks at the edge of a major lagoon, characterized by an extensive mangrove stand, in the southwest of the island (Boomert 2000: 53–68; Boomert et al. 2013: 10–16, 59–67). Two major shell midden deposits are known here, Banwari Trace and St. John, both of which can be assigned to the Ortoiroid series. Banwari Trace yielded mainly freshwater to estuarine molluscs such as pond snails and nerites in its lower levels, dated to 6000 to 5100 cal BC and consisting predominantly of marine, mangrove-adapted species such as Caribbean oysters and West Indian crown conchs in its upper portion, which had accumulated between 5100 and 4000 cal BC. This apparent alteration in shell collecting habits can be correlated to the full submergence of the Gulf of Paria by about 5150 cal BC, as a result of which the distance

between the shore and the site lessened considerably. St. John is situated closer to the Gulf and consisted entirely of marine molluscs (Reid 2011). Concurrent with the shift in shell species gathered at Banwari Trace, an alteration took place in the intensity of exploitation of the two most extensively utilized ecosystems, the locally dominating deciduous seasonal forest and the marine, inshore/estuarine habitat of the Gulf of Paria. From primarily hunting terrestrial game such as monkeys, opossums, armadillos, spiny rats, agoutis, and red brocket deer, the Ortoiroid subsistence economy evolved to fishing mainly for catfish. A variety of crabs were also caught seasonally. The Ortoiroid stone and bone tools at both sites are highly distinctive, comprising various artefacts associated with hunting and fishing, including bone projectile points for tipping hunting and fishing spears, bipointed pencil fishhooks, and similarly used bevelled peccary teeth.

The Ortoiroid people of Trinidad had sizeable ground stone axes for cutting trees and the manufacture of dugout canoes while they used small, irregular flake and core tools made of quartz, flint, or chert for a variety of purposes, e.g. cutting meat, scaling fish, prying shells open, scraping skins, finishing wooden arrowshafts, and processing vegetable fibres for making baskets. Besides, small stone mortars were used for grinding red ochre in order to obtain pigment for, e.g. body painting. Conspicuously smooth and pointed antler tips and bone needles may have been used as perforators. Crude stone choppers were perhaps utilized as woodworking tools or wedges. All in all, the men and women of Banwari Trace and St. John had sophisticated technology to effectively exploit their environment and by so doing secure a balanced diet.

Habitation sites such as Banwari Trace and St. John functioned as the dwelling places (hamlets) where especially women and children of the band lived on a semi-permanent basis. Some group members, especially the men, probably departed temporarily in order to occupy small, sometimes seasonal, camps, quarry sites, or workshops to pursue specialized tasks such as building canoes, producing stone tools, collecting vital raw materials, or engaging in subsistence activities (Boomert 2000: 64–67). The raw materials for some stone implements at Banwari Trace and St. John, such as serpentinite, greenstone, andesite, and leucodiorite, were apparently procured during overseas voyages to the Venezuelan coast, Tobago, or the Windward Islands.

Banwari Trace has yielded the oldest human skeleton of the Caribbean, the famous ‘Banwari Woman’, dating back to about 5000–4350/4000 BP. Although originally identified as a male skeleton, its gracile nature and pelvic structure suggest that it could be the remains of a woman, who, according to her dental characteristics, may have died at an age of approximately 25–30 years (Alfredo Coppa, pers. commun.). The body of this woman was carefully buried, deposited in flexed position (with bent knees) and positioned on the left side, along a northwest axis. Two

mortuary gifts were found to be accompanying the skeleton. A smooth oval pebble was encountered close to the skull and a bone needle point by the hip (Peter O'B. Harris, pers. commun.). Of course, the latter find strengthens the likelihood that this (inhumation) burial represents a woman. Groups of human bones, apparently assembled and bundled for secondary interment after exhumation of the original burials, were found as well. They illustrate a belief in the afterlife and care for the remains of the ancestors.

Blanquilla, Margarita, and Cubagua

The western Venezuelan islands such as the Las Aves and Los Roques archipelagos and the La Orchila group revealed late pre-colonial archaeological materials, indicating that they were most probably not visited by earlier populations (Antczak and Antczak 2006). These are true oceanic islands, separated from the mainland by between 135 km (Los Roques) and 155 km (Las Aves) of open deep sea. Crossing such distances seems to have been beyond the technological capacities of the early indigenous populations. However, the island of La Blanquilla, located approximately 160 km east of the island of Orchila and nearly 100 km northwest of the island of Margarita, seems to be an exception. It yielded a total of 15 archaeological sites (Antczak and Antczak 1991), and three of them, located on the flat plateaus that extend close to the small bays of the western coast, yielded only non-ceramic materials. Cultural deposits are thin with a maximum depth of 30 cm. Patches of dark soil contain remains of turtles, fish, chitons, and fragments of molluscs, including a few entire but badly weathered *Lobatus gigas* shells. Lithics are composed of various quartz flakes of irregular shapes and different sizes. Similar objects were found in a few small patches dispersed along the south coast of the island. The only identifiable artefacts are three multifacial percutors obtained from quartz pebbles, rounded by frequent use. These artefacts, together with simple quartz flakes, were grouped under the Garantón complex label and are tentatively related to the Manicuaroid series, representative of the Archaic Age of northeastern Venezuela (Antczak and Antczak 1991; see Cruxent and Rouse 1958; Ginés et al. 1946). Bone projectile points, quartz flakes, and three micro-perforators, recovered from the Cuevas de la Cabecera on the southeastern tip of the Blanquilla Island, can be assigned to this same complex.

Moving south, Margarita, the largest Venezuelan island, has yielded a series of Archaic Age finds (de Booy 1916; Castañeda Malavé 2006; Cesari 1995; Naranjo 2007). However, their abundance masks the fact that they almost entirely come from unsystematic surface surveys made by amateurs or are isolated casual findings. The Paraguachoa complex has been proposed as a unitary label that comprises various quartz artefacts such as unifacial choppers (some of up to 2 kg in weight) and a large variety of more or less finely elaborated projectile points, including pedunculated arrowheads and

dart and spear points (Cesari 1995). However, this category lumps together materials collected from barely identified sites and contexts and as such is of little use for in-depth reconstructions of the Archaic Age populations' lifeways. In 2008, human bones and lithic materials were accidentally unearthed by a machine on Margarita Island, allowing for the recovery of the relatively well-preserved remains of two individuals and associated cultural materials (Lemoine et al. 2015). The deepest of the excavated layers dates to 3670 ± 30 BP (AMS 2 sigma, 4090 to 3900 cal BP on charcoal sample). The oldest human remains date to 2270 ± 40 BP. The results of the osteological analysis show relatively tall individuals with long skulls (dolichocran) and with Sinodont dentition. These data support the claim for a marked anthropo-physical difference between the Archaic Age individuals and posterior settlers of this region characterized by brachicran or mesocran skulls (Lemoine et al. 2015). The associated archaeological materials include lithic tools, shell objects, and red ochre. Their contextual affiliations are consistent with similar Archaic Age finds reported from the Southern Caribbean and the Greater Antilles.

The archaeological materials recovered from the shell middens located at the site of Punta Gorda on Cubagua Island and in Manicuare on the mainland Peninsula of Araya, which are typical of the Manicuaroid series, suggest that the site's occupants had a strong maritime orientation. It is remarkable, however, that this series is also characterized by the presence of flat milling stones, which, according to Rouse and Cruxent (1963: 45), might have been used with grinders to process the *maguey* plant as a source of food. The chronological record begins with the Cubagua complex on Cubagua Island (2325 BC), followed by the Manicuare complex on the Peninsula de Araya (1730 and 1190 BC), and ends at Punta Gorda on Cubagua Island, where the Archaic Age materials are intermingled with trade pottery of the El Mayal Saladoid style, dated to ca. AD 100–300 (Rouse and Cruxent 1963, figs. 6, 28). The main differences between the above three complexes were drawn from the increasingly frequent use of shells as a raw material for artefact production.

Aruba, Curaçao, and Bonaire

As early as 4500 BP, the ABC islands were exploited by fishers and gatherers from the Venezuelan or maybe even Colombian littoral, who visited the islands for their rich shellfish (i.e. *Lobatus gigas*) beds. They established temporary campsites along mangrove areas and lagoons on Curaçao (Spanish Water and St. Joris), Bonaire (Lagun, Goto Lake, and Slag Bay), and Aruba (Spaans Lagoen), in rockshelters or caves on Curaçao (Rooi Rincon, associated with the largest fresh water source on the island, Ceru Boca and Tomasitu), Aruba (Arikok, Fontein, Sero Geel, associated with a fresh water source), and Bonaire (Spelonk), some bearing rock paintings executed with red pigment. However, the rock paintings may be of a later

date as is suggested by the datings from the Fontein site of Aruba, which are situated in the transition period between the Archaic and Ceramic Ages. In other words, the rock art occurring in proximity of Archaic Age sites does not necessarily have a direct relationship with the Archaic period. Other early sites on Curaçao are located at high altitudes (St. Michielsberg, Seru Coral, and Veeris) (Haviser 2001; Hoogland and Hofman 2011). The assemblages found at these sites show similarities to the El Heneal material from the northwestern coast of Venezuela in their unifacial and bifacial flakes. However, the ground shell tools resemble the Manicuaroid series of Cubagua and Margarita islands, with a particular emphasis on ground stone, bone, and shell tools (Rouse and Allaire 1978), except for the 'nipple-tip' gouge. Radiocarbon dates from the Rooi Rincon site on Curaçao have provided evidence of habitation on the island as early as 4490 ± 60 BP (Haviser 1987: 48). These people were most likely hunters and gatherers, using stone tool assemblages described as a flake/pebble tradition and diagnostic shell gouges (Haviser 1987: 47–48). The sites are found mainly in the eastern half of Curaçao (Haviser 1987: 139). The shallow deposits and resource extraction sites have been described as the reflection of a more 'nomadic lifestyle' (Haviser 1987: 139). The later Archaic Age site distribution on Curaçao corresponds closely to that of Bonaire (Haviser 2001).

Bonaire was first settled around 3500 BP, as evidenced by the Slag Bay and Lagun sites with ground shell and stone tools, hammerstones, and grinding stones (Haviser 1991; Haviser et al. 2011). At Lagun, a 'nipple-tip' shell gouge, very particular to Archaic Age assemblages, was found; such artefact was also recovered on Curaçao, notably at the St. Michielsberg site (Haviser 1987). Haviser (1991: 40) has suggested that the occurrence of this specific type of gouge is related to the movement of Archaic Age groups from Curaçao to Bonaire around 3500–3300 BP. The somewhat later Gotomeer and Slag Bay sites have ground shell and coral tools, and hammerstones, but no ground stone tools. Similarly, the unique 'nipple-tip' shell gouges have not been found here (Haviser 1991; Haviser et al. 2011).

On Aruba, a total of 22 sites have been classified as Archaic Age sites, with the oldest dates ranging around 3000 BP. These are shell scatters similar to those found on Curaçao and Bonaire. They are located in Rooi Bringa Mosa and along the banks of the gully or 'rooi' providing evidence for the exploitation of the hinterland. Much later Archaic Age sites are Canashitu (100 BC to AD 100), Boca Urirama (AD 600) and Malmok. They functioned mainly as burial grounds, while most others are shell middens or specialized activity sites (Dijkhoff 1997: 25). Malmok is known as the latest pre-Ceramic site on the ABC islands and dates to AD 300–900, at a time when there were already Ceramic Age populations on these islands as well (Versteeg et al. 1990). Remarkably, the presence of charcoal deposits in sediment layers at Frenchman's Pass (Spaans Lagoen) suggest slash/burn human activities at around 1000 BC (van Nooren 2008).

Transitions to horticulture

The seeds of the transition from Archaic to Ceramic times on the coasts and islands of the southern Caribbean should be sought for in a broader geographical perspective. Inland from the coast, the Archaic Age ways of life and economies dependent upon seafood gave way to hunting for land game, the collecting of wild vegetable foodstuffs, and riverine and lacustrine fishing. Indeed, gathering on the one hand, and domestication and incipient cultivation of plants on the other, are processes that require different knowledge and skills, but they may be closely interrelated to each other. Tight interplay between environmental and climatic factors and socially driven processes might have produced diverse forms, dynamics, and intensities of transitions from foraging to horticulture, with the imprint of space and time-related specificities. These specificities are still scantily documented in the southern Caribbean.

In part, this status quo is due to the already mentioned underrepresentation of Archaic Age deposits exposed for millennia to dramatic environmental hazards (earthquakes, tsunamis), the submergence of the coastal zone, bioturbation, and pervasive anthropogenic factors. The deficiencies of modern paleoenvironmental reconstructions and the archaeological recovery bias in the region are also culprits. Nevertheless, the overall paucity of evidence related to plant-managing and the presence of the footprints of the transition to horticulture may be expectedly 'light' (Lepofsky 2004) not only due to the predictably low demographics, but also to the existence of extensive unoccupied lands. The majority of the southern Caribbean islands were and still are predominantly arid with a relative shortage or absence of natural sources of freshwater. Horticulture of non-native species was hampered, or simply made unfeasible on dozens of low and sandy keys and on bare calcareous plateaus where small human groups could camp, but not cultivate. Native plants were undoubtedly in use as was the case of the above-mentioned indigenous exploitation of the agave plant (*Agave cocui*) on the ABC islands. It was from the mainland coasts that the horticulturalist know-how of non-native cultigens had to be selectively imported and put to trial on some of the larger southern Caribbean islands such as Trinidad, Margarita, and the ABC islands.

The ground stone tools of the Ortoiroid people at the Trinidad sites of Banwari Trace and St. John suggest that the processing of wild or even domesticated edible plants formed a major aspect of their subsistence economy which may have been highly diversified, resulting in a truly broad-spectrum diet. Apart from hunters, fishers, and gatherers, these Amerindians were true incipient horticulturalists (gardeners). Indeed, many of the stone implements used by the Banwari people were intended for the processing of plant foods (Boomert 2000: 58). Analysis of starch grains trapped in fissures and pores of stone pestles found at St. John yielded evidence that the Archaic Age inhabitants at this site consumed maize (corn),

chili peppers, and ground provisions such as sweet potatoes, Indian shot (*achira*), perhaps Indian yam, and coontie (*zamia*) (Pagán Jiménez et al. 2015). The latter is a highly toxic, wild tuberous plant which was perhaps tended by the inhabitants of St. John. Processing coontie would have involved grinding the tubers into mash that had to be left to ferment until maggots appeared, which signalled their detoxification. Further research is necessary to deepen our understanding of the horticultural practices of the Banwari Trace occupants.

A combination of hunting, fishing, gathering, and incipient horticulture would characterize Trinidad's Amerindian subsistence practices until the end of the Archaic Age on the island, ca. 200 cal BC. Typically bottle-shaped stone pestles, anvils, axes, and grinding stones have been found at a possibly temporary (seasonal) camp site at Poonah Road in central Trinidad. They closely resemble similar tools encountered at the oldest Archaic Age sites of Tobago, belonging to the Milford complex, dated to 3500/3000 cal BC (Boomert 2000: 75–77). Several archaeological sites in Trinidad can be dated to the late Archaic Age. The best known of these are Ortoire and Cocal 1 shell middens, situated close to each other on top of a sand bar, close to the east coast of the island (Boomert 2000: 84–87; Boomert et al. 2013: 16–18). Both sites are made up of primarily marine bivalves at home in a muddy, sandy-bottom habitat, including trigonal tivelas and donax clams. The Ortoire site yielded several clay hearths showing abundant ash, charcoal, fire-cracked stones as well as burned shells and bones. Large quantities of red ochre pebbles and flat, tabular heating (cooking) stones of local sandstone were found at both sites. Apart from shellfish collecting, hunting, fishing, and probably incipient horticulture formed major subsistence activities. Ground stone tools include hammerstones, small stone mortars, occasionally showing red colouring due to the grinding of hematite, pitted anvils for the cracking of palm nuts, and grinding stones. Most of them are made of local quartzite, although the presence of pieces of blackish dolerite at Ortoire suggests precolonial contacts with Tobago. Pieces of quartz crystal are numerous at both sites. At present such quartz chips are prized shamanic charms thought to possess curative properties among the Warao and other Amerindian peoples of the mainland. Moreover, quartz or quartzite pebbles often serve as healing stones, symbolizing guardian spirits in the gourd rattles used by the local religious specialist, the shaman, to contact the spirit world.

On Margarita Island, the presence of grinding stones recovered from the El Tirano site suggests the processing of plants and/or mineral ochre, colorants, and/or coarse salt by ca. 4000 BP. Whether other stone objects resembling large adzes with little or no use wear from this same site might have been used for horticultural purposes is disputable. Rouse and Cruxent (1963: 58) hypothesized that on Margarita the Archaic Age Manicuaroid gatherers-fishers-hunters continued their Archaic mode of life until the first centuries AD. It was after AD 300 that pottery-making Saladoid

horticulturalists entered the islands of Margarita and Cubagua and replaced or merged with the local Manicuaroid people (Rouse and Cruxent 1963: 58, figs. 6, 28; see de Booy 1916).⁶ Rouse and Cruxent (1963: 59) further suggested that the mountainous areas of northeastern Venezuela may have halted the advance of the riverine-oriented Saladoid people who proceeded down the Orinoco River. This delay could have permitted the Archaic Age peoples to survive in relative isolation from the rest of the country where agriculture and the pottery-making technology were already widespread (Rouse and Cruxent 1963: 59). A closer look at the more recent research on Archaic Age remains from the northeastern coast and farther inland may shed light on this issue.

Sanoja and Vargas-Arenas (1999a), synthesizing the historical processes on the northeastern coast of Venezuela between 7000–6000 and 2000 BP, distinguish three ‘modes of life’ characteristic of an increasing development and consolidation of social ties: (1) reciprocal solidarity, (2) organization of social labour, and (3) the emergence of a locus of authority. While the first two modes were linked to the typical Archaic Age traditions of gatherers-fishers-hunters,⁷ the third one was defined on the basis of evidence of transition from foraging to horticulture and sedentarism. The prime example of this mode of life is the Las Varas site, situated on the elevated paleoshores of the Campoma Lagoon, at the base of Araya Peninsula, in the state of Sucre and dated to ca. 2600 BC (Sanoja 1989: 529). The subsistence of its occupants depended on the exploitation of resources drawn from various ecosystems rather than on mangrove-associated foodstuffs. Sanoja and Vargas-Arenas (1999a: 153) recovered a diversified assemblage of wood, bone, and lithic tools at Las Varas, including conical grinding stones (*manos*), adzes which were probably used for horticulture, small globular pottery vessels, stone and shell biomorphic carvings, and bird bone inhalers. From ca. 4000 BP onwards, close interrelations between the typical Archaic Age Manicuaroid people and the occupants of Las Varas became established on the basis of barter between the mainland and the island settings. Purportedly, this intersocietal interaction—or even alliance—was responsible for the widespread presence of both the Las Varas lithic artefacts (including conical *manos*) and Manicuaroid shell adzes and gauges (*gubias*) at sites along the Venezuelan coast and in the insular Caribbean (Sanoja and Vargas-Arenas 1999a: 154). To the west of the Araya Peninsula on the northeastern Venezuelan coast, early horticulture-related artefacts were found at the above-mentioned Pedro García site, dated to 2450 BP. The conical stone pestles and platters of this site resemble those recovered at Las Varas, while its shell gauges duplicate those from the Manicuaroid and Cubagua sites (Rouse and Cruxent 1963). Further west, similar artefacts have been recovered in the Lake Valencia Basin (see later). Sanoja and Vargas-Arenas (1999a: 155) conclude that the transition towards sedentarization and tribalization among the foragers of the northeastern coast of Venezuela commenced towards 4600 BP. However, at this time, these societies appear to have

already accumulated a rich experience in both managing and processing certain vegetal resources. The early Archaic Age populations of the northeastern coast of Venezuela and, by extension, the adjacent southern Caribbean islands, were undoubtedly influenced by the populations of the Orinoco River Basin to the south. In the Lower Caroní River region, the Archaic El Espino tradition (ca. 8000–3750±80 BP) is characterized by artefacts made from milky or crystalline quartz that are lacking in projectile points. The bearers of this tradition inhabited open campsites and rock shelters along the margins of the river. In some of the shelters the first rock paintings appeared by 3500 BP (Sanoja and Vargas-Arenas 2007: 183). The transition from a hunter-gatherer economy to one based on horticulture began by 3000 BP when grinding stones (*manos de moler*), percutors, and axes began to appear. By 2810 BP, these artefacts were ubiquitous in the region, signalling the end of the Archaic Age and the settling of groups of horticulturalists and potters who arrived at the Lower Caroní by 3000 BP (Sanoja and Vargas-Arenas 2007: 183). A rough core-and-flake lithic industry (scrapers, drills, and choppers) has been found in the Cueva del Elefante rock shelter near the confluence of the Orinoco and Caroní Rivers. It was accompanied by grinding stones used for processing plant foods (graters, *manos*, and stone bowls), and has been dated to between 2440±85 and 2320±100 BP (Sanoja 1977).

In Orinoquia, the specificities of the transition to vegetal food-producing economies are badly known. Rouse and Cruxent (1963: 51) set 1000 BC as the date for the beginning of the Neo-Indian epoch, arguing that this is the earliest date that attests to intensive agriculture in Venezuela. This date was associated directly with the presence of Saladero style pottery on the Lower Orinoco River.⁸ More recently, Sanoja and Vargas-Arenas (1999a: 123) have suggested that the final phase of the Archaic Age hunter-gatherer formations in the Orinoco Basin may be dated to between 5000–2500 BP, implying that the transition from foraging towards horticulture was already underway by these dates. According to Zucchi and Tarble (1984: 179), in the Middle Orinoco area incipient horticulture was probably practiced already by 2950 BP during the initial occupation of the Agüerito site, accompanied by the manufacture of pottery and a subsistence economy based on hunting, fishing, and gathering. Barse (1995: 112) concludes that in the Upper Orinoco region the Archaic traditions could have remained until the appearance of horticulture, some 3000 or 4000 BP.

Any discussion of the post-Archaic Age developmental trajectories in the Orinoco Basin, as well as in the Venezuelan llanos and Andes is not possible in this chapter because of space constraints. Clearly, the transitional processes from foraging to farming that had been taking place in these regions and their timing were synchronized with those occurring in the southern Caribbean. Our discussion now turns to north-central Venezuela, a region which, as we will argue below, played a pivotal role in experimenting, receiving, transforming, and retransmitting the horticultural

innovations and experiences to the adjacent neighbouring coasts of the southern Caribbean.

The north-central Venezuelan region is a rich combination of distinct ecosystems and landscape features and has been portrayed as a cultural cross-roads of influences and/or population movements to and from the Andean to the west, the Caribbean to the north, and the Tropical Lowlands to the south (Cruxent and Rouse 1958; Osgood and Howard 1943).⁹ The core feature of this region, Lake Valencia, is the largest permanent freshwater and endorheic lake in lowland South America, north of the Amazon (Berry 1939; Binford 1982; Bradbury et al. 1981; Leyden 1985; Schubert 1978, 1980). The lake is situated 27 km as the crow flies from the Caribbean coast and separated from it by the Cordillera de la Costa mountain range. Leyden (1985: 1279) noted that the lake area “is one of few sites to provide paleoecological data for the Neotropical Lowlands” of South America. Moreover, Curtis et al. (1999: 609) indicated that Lake Valencia is located near the marine Cariaco Basin just off the Venezuelan coast “that has yielded high-resolution palaeoclimatic information providing the possibility of correlating marine and terrestrial palaeoclimate records.” The lacustrine environment and the fertile valleys around the lake formed a magnet for human populations, probably from the Late Pleistocene onwards. Although verifiable Paleo-Indian materials are unknown from the basin, and the only relevant lithic projectile point was reported from the nearby locality of Bejuma to the west (Dupouy 1945), deposits of at least 17 species of extinct Pleistocene megafauna (one *Megatherium* bone has been dated to ca. 10200 BP) have been reported (Carrillo et al. 2008: 245; Peñalver Gómez n.d.). Therefore, this region might have been known to, if not frequented by, the peoples of the Lithic Age Joboid series reported from the states of Falcón and Lara in western Venezuela (Ochsenius and Gruhn 1979; Oliver and Alexander 1990). Paleoecological studies from Lake Valencia’s sediment, deep/shallow core and geological analyses indicate that starting by 8300 BP, the vegetation around the lake changed to essentially modern conditions (Bradbury et al. 1981; Leyden 1985; Rull et al. 2010). In some areas between 8300 and 5200 BP, the *Chenopodium*-*Amaranth* communities display a decrease of arboreal pollen influx (*Trema*, *Cecropia*), suggesting a drier, open forest and interspersed woodland-savanna. Between 5200 and 2200 BP a semideciduous to semi-evergreen forest, with increased *Trema*, *Spondias*, *Cecropia*, and *Acalypha* expanded again, while a shrubby and herbaceous (*Chenopods* and *Amaranth*s) vegetation continued by the shoreline of the lake (Leyden 1985: 1292–1293; Schubert 1980). The pollen recovered for this interval was not adequately analysed to the species level with respect to incipiently domesticated plants and, surprisingly, no evidence of domesticates was identified for the period following 2200 BP. However, by the first centuries AD and probably earlier, archaeology indicates the intrusion of horticultural groups into this region, which may call for the ecodynamic (cf. Kirch 2007) re-evaluation of the

above sequence of paleoclimatic and ecological changes in relation to human intervention.

Though scant, the evidence indicates the presence of Archaic Age groups in the Valencia Basin by 4000 BP. The Michelena site, located near the present city of Valencia, has yielded conical pestles and flat ground stone implements. These artefacts suggest the processing of plant materials characteristic of the early horticulturalist lifestyle (Cruxent and Rouse 1958). Moreover, at the site of El Morro de Guacára, on the northern lake shore, Peñalver Gómez (n.d.) recovered a human burial with an *Oliva* sp. shell necklace. The bones were radiocarbon dated to 4400 BP, but lack depositional data. This precludes further elaboration of the data beyond the fact that the remains seem contemporary with the Michelena complex and its possible transitional materials. Indeed, the open woodlands and savannas of Chenopodiaceae-Amaranthaceae communities (Leyden 1985), prevalent since 8300 BP in the lake's floodplain 'weed environment', may be considered as a good ecological context predicted by Anderson (2005) for the eventual ennoblement of seed plants (José Oliver, pers. commun. 2000).¹⁰ For now, the lack of sufficient and adequate paleobotanical and ecological data collected from inland (non-lacustrine) and archaeological contexts (settlements, potential cultivating areas), leaves the hypothesized history of paleoecological changes without a human signature.

The archaeological evidence indicates the presence of agriculturist, ceramic-making groups in north-central Venezuela by the first centuries AD. These groups were the producers of the pottery of the Tocuyanoid series, characterized by distinctively curvilinear polychrome painted designs and secondary burials in ceramic vessels. The Tocuyanoid groups originated somewhere in Lara State to the southwest and expanded into Yaracuy Valley, and then to the east along the central coast (Arvelo 1995; Cruxent and Rouse 1958; Oliver 1989, 1997). Their presence is limited to the central coastal zone (Ocumare and Cerro Machado sites [Antczak and Antczak 2006; Cruxent and Rouse 1958]), where they established settlements seemingly amidst local Archaic Age populations. Their interactions with and impact upon the Archaic Age marine-oriented groups is to date unknown. Around AD 200–300, a different horticulturalist group, the producers of the Barrancoid pottery, migrated from the middle-lower Orinoco River towards Lake Valencia (La Cabrera complex) and the Southern Caribbean coast in the area of Puerto Cabello (El Palito, Aserradero [Cruxent and Rouse 1958; Velázquez Romero 2014]). Elaborate plastic decoration is a hallmark of Barrancoid ceramics. It is the invasion of Barrancoid horticultural groups into the Lake Valencia area that broadly correlates with the above-mentioned significant decline of forest vegetation and the expansion of savanna grasslands suggesting that these shifts may be a direct consequence of the invasion and the related increasing human disturbances due to horticultural practices. Although Archaic Age populations of the Valencia Basin (e.g. Michelena, Guacára) were not isolated from the innovative early

horticultural ideas that were already spreading across the Orinocan south and Andean piedmont to the west by 4000 BP (Arvelo 1995; Arvelo and Oliver 1999; Gassón 2002; Roosevelt 1980), the archaeological record indicates that this basin may have in fact been a 'secondary' or 'receptive' centre (Pearsall 1995). This poses interesting questions about the nature and dynamics of interactions between its Archaic Age residents, the invading Tocuyanoid and Barrancoid groups, and the dispersals of innovative ideas to the neighbouring areas, including the southern Caribbean coasts and islands. It also poses a pressing question as to whether any cultigens were used by Archaic Age populations before the agro-ceramist incursion into the region.

The Archaic Age record on the ABC islands might have been related to the above-mentioned mainland processes. The ceramics found in the upper levels of the Slagbaai and Gotomeer sites on Bonaire are suggestive of a transition to the Ceramic Age (Haviser 1991: 40–41; Haviser et al. 2011). The Wanapa site on Bonaire also provided an early date of 1050 BC. It yielded heavily patinated shell artefacts and large *Melongena melongena* and *Pecten ziczac* shells, and may be demonstrative of the absorption of Archaic Age peoples into the Ceramic Age populations (Haviser 1991: 60). The first appearance of ceramics on Bonaire dates to around AD 470. However, the temporary campsites of the Spanish Water lagoon on Curaçao provide evidence of pottery associated with otherwise Archaic Age toolkits and shell assemblages, dating to between ca. 500 BC and AD 200 (Hoogland and Hofman 2011, 2015; Hoogland et al. 2015). The coarse fabric of this pottery is clearly different from the Dabajuroid ceramics which typify the Late Ceramic Age on the ABC islands. It should be noted that Du Ry (1960: 94) and van Heekeren (1960: 115) reported pottery intermingled with Archaic Age assemblages on Aruba suggesting the possible survival of these early populations until the onset of the Ceramic Age. Possible evidence for interactions between Archaic and Ceramic Age populations can be related to the presence of five potsherds decorated with incised cross-hatched lines, found at the Sta. Cruz Ceramic Age site on Aruba. Rouse and Cruxent (1963: 110) considered that these Río Guapo style (AD 270) trade sherds from the central-eastern coast of Venezuela, might have been considered as ancestral to, or an offshoot of, the Saladoid series. Oliver (1989: 3) speculated that this intrusive pottery could be the result of direct contact between Aruba's resident Archaic Age peoples and the bearers of the Guapoid-Ronquinoid Tradition from the coast of Venezuela.

While some archaeological data from the ABC islands yield clear evidence of Amerindian plant use in the Archaic Age, others provide ambiguous results. Versteeg (1991) applied isotopic analysis of total bone collagen to dietary reconstruction of ancient populations in the Caribbean region and compared the consumption of three food categories (marine food, C3, and C4 plants) by the Malmok (Archaic Age), and Santa Cruz and Tanki Flip (both Ceramic Age) individuals. The results of the analysis were puzzling as

they showed uniformity between the Archaic and Ceramic Age samples, i.e. the isotopic composition of bone collagen did not change. Interestingly, Mickleburgh and Pagán Jiménez (2012: 2472) reported that an individual from the Archaic period site of Canashito on Aruba (ca 350 BC to AD 150) “yielded a relatively high number of maize starch grains, with evidence of grinding and baking.”

Concluding remarks and future research

The long-term historical perspective used in this chapter allows us to perceive that the early ways of life and subsistence strategies in the southern Caribbean might have been the product of rather slow colonization processes, interspersed with episodes of rapid migration. Furthermore, the ‘spread’ of horticultural know-how across the southern Caribbean coasts and islands appeared not to be an advancing ‘mega-wave’, but could be better described as a mosaic of events—at times lengthy and at other times punctuated (see Leppard 2014). These complex developments were sometimes either enabled or constrained by environmental changes, regional characteristics, and seasonality. These developments were also mediated by the socio-cultural contingencies of local groups, although the vast majority of causal mechanisms that drove them remain undetermined. If we aim to understand the transition from foraging to farming in the southern Caribbean in terms of dated events rather than a general sequence of long chronological periods (see Barrett and Ko 2010: 289), we need to have at our disposal at least four sets of reliable data. These data comprise the building blocks necessary for the (re)construction of more robust and nuanced histories of the early developmental trajectories of the indigenous societies across the southern Caribbean region.

First, we need more radiocarbon dates and also more accurate dating. For example, the quantification of the local marine reservoir effect for the southern Caribbean region is crucial for establishing accurate archaeological chronologies (Fitzpatrick and Rick 2015). The experience derived from the analysis of land and marine shells in the Brazilian shell middens or *sambaquis* for the purpose of calculating reservoir corrections and temporal variations may prove important to Caribbean research (Carvalho et al. 2015; Macario et al. 2015). However, addressing more general questions about what is actually being dated and for which reason, should be standard archaeological practice. Current chronology shows that since the onset of the Holocene, scattered groups of small-game hunters, fishers, and foragers were already present in the northern portion of the South American mainland. Their incipient plant resource management corresponds with similar signatures observed elsewhere on the continent (Borrero 2015: 130). However, significant temporal gaps arise among geographically not-so-distant southern Caribbean islands when we look at the earliest dated presence of the Archaic Age peoples: Trinidad ca. 7790 BP, Margarita 4000 BP, Curaçao 4500 BP,

Bonaire 3500 BP, and Aruba 3000 BP. How can we explain the gap of ca. 3790 years between the earliest dates found on nearby Trinidad and Margarita, or of ca. 1500 years between adjacent Curaçao and Aruba? These gaps may be related to the above-mentioned adverse preservation conditions as well as to recovery bias, the timing of large-scale migratory movements on the adjacent South American mainland, the pace of local developments, or to a combination of these four factors. We should admit that we do not yet have sufficient control over dated events in the study region. But such control is necessary to inform deep-in-time perspectives and broader interregional generalizations.

An improved chronology should be tightly interwoven with the second set of data, namely reliable reconstructions of specific paleoenvironments in which and through which early settlers and their successors were shaping their everyday existence. The loci awaiting sediment coring lie not only within but also beyond the Archaic Age middens. Recovered samples from deep to shallow coring probes may help to detect and understand anthropogenic signatures of land use and their dating (Siegel et al. 2005, 2015). Stratified sediment core/auger samples collected from each of the major ecological zones defined within a given study area should render a more comprehensive paleoecological and paleoenvironmental diachronic reconstruction of the southern Caribbean, especially as regards the presence or absence of habitats that might have been liveable for early populations.

The third set of building blocks will result from attempts at disclosing the ‘performances’ of the early human societies that were extant in the above-mentioned specific spatiotemporal frames. In particular, analyses utilizing next-generation sequencing (NGS) technologies represent a powerful tool for refining our understanding of past migratory movements, responses to environmental challenges, and processes that arose during Archaic-to-Ceramic-Age transitions in the study region (Moreno-Estrada et al. 2013; see also Olalde et al. 2015). Archaeogenetics can also shed light on the specific effects invading horticultural groups had on Archaic Age inhabitants. These processes are barely known in the southern Caribbean. In them is hidden the diversity, though unspecified, of interactions. Notwithstanding the paucity of data, current explanations seem to support historical continuity rather than the replacement of the invaded by the invaders. Toro-Labrador et al. (2003) showed that almost 70% of Amerindian mtDNA on Aruba belongs to the same haplogroup, although the archaeological evidence seems to point another way, indicating that the Ceramic Age people who settled this island after AD 1000 were physically distinct from its previous Archaic Age populations. However, a recent study of a more representative sample (N=144) from Aruba showed that 53.3% consisted of Amerindian mtDNA (44% haplogroup D and 12% haplogroup C) (Carrero-González et al. 2010). The presence of the haplogroup C, representing pre-Ceramic or Archaic Age Amerindians suggests that a symbiosis occurred between them and the Ceramic Age populations of Aruba. These data strongly suggest that

the continuities and discontinuities between Archaic and Ceramic Age populations in the southern Caribbean and adjacent areas should be analysed case by case by interdisciplinary teams on the basis of adequate sampling.

To access this third set of data, it is necessary to shift attention from the Archaic Age shell middens *per se* to viewing them as an integral part of a wider cultural landscape. This refocusing has already been suggested with respect to off-site coring and paleoenvironmental reconstructions. In the southern Caribbean, shell middens were traditionally assumed to be refuse dumps and by-products left behind by several generations of indigenous peoples. The molluscs contained in the middens were not conceived of as participants in human-mollusc interaction processes (Antczak et al. 2007). In other words, the shells recovered in the middens were seen solely as by-products of a one-sided process. Because the conspicuous middens in themselves dominated almost all the attention of researchers, systematic excavations outside the middens were not performed. Therefore, information on Archaic Age settlement layouts, house structures, and microregional settlement patterns have remained largely undisclosed. However, features of possible Archaic Age residential units were recently recovered in southern Puerto Rico (Rivera-Collazo 2011; Rodríguez López 2004; Rodríguez Ramos 2008), on St. Martin (Bonnissent 2013), and at Plum Piece on Saba (Hofman and Hoogland 2003; Hofman et al. 2006). These results should encourage large systematic on-site as well as off-site excavations across the southern Caribbean coasts and islands.

Although the exponentially accelerated sophistication of archaeological methods, techniques, and theoretical approaches reflected in the results of recent investigations is encouraging, gathering new archaeological evidence is essential. Applying cutting edge technologies to archaeological discoveries can bring to light highly significant evidence, for example the foregoing archaeogenetics or the recent analyses of starch grains (Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez et al. 2015). But this fourth building block in ideal (re)constructions heavily depends on new fieldwork data. Such interdisciplinary undertakings are particularly urgent on the larger southern Caribbean islands that have been exposed to human disturbances resulting from rapidly progressing urbanism and tourism development.

We are confident that the data contained in the above-mentioned building blocks will ‘better feed’ agent-based simulations which would allow us to test our assumptions on the nature and dynamics of Archaic Age socio-natural systems (c.f. Lake 2015). In addition, the interlocking of these building blocks will, over time, allow us to more critically reassess the ontological differences between ‘them’ and ‘us’. Hopefully, an interdisciplinary synergy will also enable us to dissolve the dichotomy between “walking stomachs and talking heads” (Antczak and Antczak 2008; Gamble and Roebroeks 1999: 10; Hofman et al. 2006) allowing us to approach these early peoples of the southern Caribbean as they were: simply living ‘their worlds’.

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Notes

- 1 By endowing the Southern Caribbean with characteristics originally attributed to the entire continent we are aware that human-related paleoenvironments on the northern Venezuelan coast and islands are better studied for the Archaic period (Bryan 1973; Oliver and Alexander 1990), while the inland regions are known through wider time-span interrelations (Montoya and Rull 2011; Montoya et al. 2011; Rull et al. 2015).
- 2 In contrast to 'agriculture', 'horticulture' implies the use of hand tools to grow domesticated plants, and does not require the use of draft animals or the application of complex irrigation or fertilizers (see Leach 1997; for horticulture as a low-level food production system, see Winterhalder and Kennett 2006: 4). In tropical forest societies horticulture may be seen as an "opportunistic activity based [sometimes] on the intense and sophisticated management with stone axes of gardens and forest under different stages of ecological succession" (Góes Neves 2013).
- 3 Rouse and Cruikshank (1963: 22) defined four subsequent 'epochs' connecting technology with subsistence strategies in Caribbean culture history: Paleo-Indian (15,000–5000 BC), Meso-Indian (5000–1000 BC), Neo-Indian (1000 BC to AD 1500 [sub-divided into three Periods]), and Indo-Hispanic (AD 1500 to present). Later, Rouse (1972: 136–138) redefined the epochs in purely technological terms to 'ages': Lithic (4000–2000 BC), Archaic (2000–500 BC), Ceramic (500 BC to AD 1500), and Historic Age until the present. The latter scheme is adopted here.
- 4 Note that we include the island of Trinidad into the Southern Caribbean Region (cf. Newsom and Wing 2004, figs. 4.1 and 5.1, 58).
- 5 It is important to note that the islands of Trinidad and Tobago were both connected to the South American mainland until the peak of the Wisconsin glaciation, ca. 18000 BP. Due to the posterior melting of the continental ice caps the eustatic transgression interrupted the landbridge between Trinidad and Tobago during the Late Glacial Period, ca. 13000–10000 BP. Trinidad remained connected to the mainland by a landbridge in the southwest until ca. 8000 BP; the Gulf of Paria became completely submerged by 6200 BP (Boomert 2000: 41–42, 44).
- 6 According to Sanoja and Vargas (1999a: 157), the Middle Orinoco migrants stabilized on the northeastern coast of Venezuela between AD 100 and 280, following their arrival a few centuries earlier.
- 7 The first mode was ascribed by Sanoja and Vargas (1999a: 150) to the aforementioned shell middens at Ño Carlos and Remigio, while the second one would be related to the similar deposits at the Guayana, Manicuare, and Cubagua sites (the latter two originally reported by Ginés et al. [1946] and Cruikshank and Rouse [1958]).
- 8 Two main competing chronologies regarding the Saladoid origins are in vogue: (1) a 'long chronology' that puts the date of the appearance of Saladoid white-on-red painted pottery at between 4450 and 2150 BP (Rouse 1978; Roosevelt 1987, 1997), and (2) a 'short chronology' that argues for the Saladoid origins at 2550 BP and considers the painted pottery an intrusion from the west (Vargas-Arenas 1981, 1990);

see also Boomert (2000) and Gassón (2002) for summaries of additional discrepancies with regards to the origin and spatial dispersion of Barrancoid pottery.

- 9 In the Caribbean Culture Area, defined by Rouse (1962) as comprising central and eastern Venezuela, the Caribbean islands (West Indies) and the coastal plains of Guyana and Western Suriname, central Venezuela (of which its north-central portion discussed here is a pivotal part) has been considered as a transitional or interlocking zone between the Intermediate Area to the west and Amazonia to the south and east.
- 10 It has been generally assumed that weeds developed concomitantly with plant cultivation. However, their presence may be indicative not only of early anthropic disturbances of the local environment, but also of small-scale attempts at horticulture (see Snir et al. 2015).

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Part II

Animal domestication



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6 Animal management and domestication in the realm of Ceramic Age farming

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Introduction

Questions regarding the antiquity, emergence, and practice of farming are often considered in tandem with how we think about the rise of plant and animal domestication, as well as the various roles domestic animals play within a society (Crabtree 1993; Gumerman 1997; Russell 2002; Smith 2001; Zeder 2008). In the past, as is the case today, the ways in which people conceived of, accessed, manipulated, prepared, and consumed animal and plant resources were highly variable, and often do not fit constrictive or essentialist conceptions of hunting, fishing, foraging, or farming (Gremillion 2011). During the Caribbean Ceramic Age, indigenous peoples practiced a variety of subsistence strategies and food production techniques, including simultaneous farming, foraging, hunting, and fishing as well as various combinations of these activities. In this chapter, we discuss the topic of domestic and managed animals among later Ceramic Age (AD 500–European Contact) farmer-fisher-hunters of the Caribbean islands where archaeological evidence for the uses and roles of domestic and managed animals is highly situational across space and time and cannot be uniformly characterized within the West Indies.

In contrast to other regions of the Neotropics and surrounding continental mainland, the Caribbean islands do not have natural populations of sizable terrestrial animals that could have been the focus of domestication efforts resulting in fully domesticated animals (e.g., llamas (*Lama glama*), alpacas (*Vicugna pacos*), turkeys (*Meleagris gallopavo*), or Muscovy ducks (*Cairina moschata*)). One possible exception to this biogeographic trend is the continental islands of Trinidad and Tobago off the coast of Venezuela where terrestrial mammalian biodiversity is higher and more abundant than on the islands of the Greater and Lesser Antilles (Boomert 2000: 32). During the pre-Columbian period, the terrestrial fauna of Trinidad and Tobago included taxa such as monkeys (e.g., *Alouatta seniculus*, *Cebus albifrons*), opossums (*Didephis* sp.), agouti (*Dasyprocta* sp.), paca (*Agouti paca*), deer (Cervidae), tapir (*Tapirus terrestris*), and peccaries (*Tayassu* sp.) (Boomert

2000; see also Steadman and Jones 2006; Steadman and Stokes 2002). Currently, however, there is no evidence suggestive of animal domestication among these taxa. Furthermore, although there are several large aquatic mammals in the Caribbean region, including the now extinct West Indian monk seal (*Monachus tropicalis*), the (vulnerable) West Indian manatee (*Trichechus manatus*), dolphins, and cetaceans, none of these were good candidates for domestication.

Also, unlike the Pacific Islands where people intentionally introduced domestic pigs (*Sus scrofa domesticus*) and chickens (*Gallus gallus domesticus*) to numerous islands, the human colonizers of the Caribbean did not transport either large domesticated mammals or birds that were primarily destined to serve as food items. To date, only two domestic animal taxa have been recovered from pre-Columbian archaeological contexts in the Caribbean, the domestic dog (*Canis lupus familiaris*) and guinea pig (*Cavia porcellus*). Neither animal was native to the Caribbean islands and both were domesticated prior to their anthropogenic introduction from South America (Blick et al. 2016; LeFebvre and deFrance 2014; Leonard et al. 2002). In addition to domestic dog and guinea pig, it has been suggested that other non-domesticated South American-introduced taxa may have been well-suited to human manipulation and management, including agouti (*Dasyprocta* sp.), opossum (*Didelphis* sp.), and armadillo (*Dasyurus* sp.) (Giovas 2017; Giovas et al. 2012; Wing 2001). Similar suggestions have been made about the possible human management of hutia (Family: Capromyidae), a group of rodents endemic to the Greater Antilles and The Bahamas (Colten et al. 2009; Garner 2001; LeFebvre et al. 2018; Morgan and Woods 1986; Wing 2008).

Yet, within Caribbean archaeology, our understanding of human animal management and the nature of human relations with domestic or other manipulated fauna is not clear in terms of intentionality, motivation, cultural significance, and perhaps most importantly, archaeological evidence. Possible exceptions to this statement are archaeological records of domestic dog. Domestic dog remains are well-studied in Caribbean archaeology, addressing an array of topics such as subsistence patterns, hunting strategies, ritual activities, and human movement and interaction within the circum-Caribbean region (Blick et al. 2016; Laffoon et al. 2015, 2017; Plomp 2011; Roe 1995; Wing 2008). When domestic dogs were introduced to the Caribbean islands they likely fulfilled many roles, such as hunting companions, pets, and possibly sources of food.

In this chapter, we use evidence of domestic guinea pig and hutia species' exploitation and translocation to consider how we might better recognize and study intentional human manipulation of these animals. Thus far, the archaeological evidence indicates that the inter-island transport of animals was not a prominent feature of the pre-Ceramic or pre-Arawak Archaic populations. Building on previous research by others (see Newsom and Wing 2004; Wing 2008), and contextualized within broader interdisciplinary and

contemporary theoretical and methodological discussions about domestication and animal management, we discuss the ways in which human interactions with guinea pigs and hutias in the past contributes to how archaeologists define and recognize “domestication” as a process versus an outcome.

Following an overview of archaeological approaches to the study of domestic and managed animals, we summarize previous and current research regarding pre-Columbian guinea pigs and hutias in the Caribbean. Based on this overview, we then discuss current thinking regarding guinea pig and hutia management across the region. We argue that more attention is needed on the commensal and symbiotic relationships that Ceramic Age populations had with both guinea pigs and hutias. Our analysis indicates that a rigid concept of “domestic” does not provide a broad enough framework for elucidating farmer-domestic animal interactions in the Caribbean region, but rather that animal management probably followed variable pathways. Finally, we highlight current research agendas and suggest avenues of future study, emphasizing the generation of empirical data and challenging traditional approaches to animal management and domestication in the region.

Archaeological approaches to “domestic” animals and related challenges

Archaeological records of domestic animals provide inferential evidence of a myriad of past cultural and social practices, including subsistence economy, political economy, organization of labor, networks of interaction, and expressions of identity and social status. What constitutes a domesticated animal as well as when and where an animal was domesticated are seminal topics of debate in archaeology, including the origins, processes, and motivations for domestication (e.g., Bruford et al. 2003; Smith 2001; Terrell et al. 2005; Zeder 2015; Zeder et al. 2006). Furthermore, how one defines a “domestic” animal is integral to understanding the human/animal relationship as well as the place of that relationship in human and animal life histories (Russell 2012).

As reviewed by Russell (2012: 208), processes of animal domestication are inherently both biological and social (see also Mengoni Goñalons and Yacobaccio 2006). Biological perspectives of domestication tend to focus on human control over animals with particular emphasis on control over breeding and/or almost all facets of continued animal survival (e.g., Albarella et al. 2006). On the other hand, social perspectives tend to favor broader interpretations of the sociocultural incorporation of animals into human practices, with culturally relative thresholds or outcomes (Russell 2012). It is important to note that both biological and social perspectives of animal domestication are not mutually exclusive. To that end, Zeder (2012: 228) describes a “centrist” perspective that recognizes mutual benefits to both humans and animals in processes of

animal domestication. She highlights the idea that the mutualism is asymmetrical:

[d]riven by the human ability to spontaneously invent new behaviors that maximize the return of a desired plant or animal resource and, most importantly, to pass on the behaviors that best meet these goals to their offspring and to others through social learning.

(Zeder 2012: 228; see also Zeder 2006, 2015)

Along these lines, theoretical perspectives of animal domestication (e.g., biological, social, centrist) influence the analytical recognition and methodological documentation of domestic animals in the archaeological record. For example, a biological perspective is likely to favor evidence of measurable morphological and/or genetic differences between a “domestic” animal and its “wild” progenitor, whereas a socially inclined perspective may draw more heavily on ancillary evidence such as changes in butchery techniques suggestive of differential treatment, but not necessarily morphological differences, between “domestic” and “wild” animals (Russell 2012: 256–259). However, as argued by Zeder (2006: 178): “There is no one-size-fits-all approach to documenting animal domestication.” Therefore, regardless of theoretical perspective, archaeological discussions and documentation of domestic animals in the past must be geographically, environmentally, and temporally contextualized according to the particular culture, people, and animal of study (e.g., Mengoni Goñalons and Yacobaccio 2006; Terrell et al. 2005).

Moreover, archaeologists have argued that animal domestication should not be viewed as an end point in our comprehension of human-animal relationships, but rather domestication should be conceived of as one component along a continuum of activities and aims that are tied to human strategies of animal and plant manipulation, management, and cultivation (Terrell et al. 2005; Vigne 2011; Zeder 2015). According to Zeder (2015: 3192), the management of wild animals or plant species is a necessary foundation to eventual domestication and the onset of agriculture; however, management of a species does not necessarily result in the emergence of a domestic. We think this distinction is important and support Zeder’s (2015: 3192) definition of management as “the manipulation of the condition of growth of an organism, or the environment that sustains it, in order to increase its relative abundance and predictability and to reduce the time and energy required to harvest it.”

After the management of targeted species, Zeder (2015: 3192) describes three general pathways through which a species (animal or plant) is likely to be domesticated: 1) the commensal pathway, 2) a prey or harvest pathway, and 3) a directed pathway. The commensal pathway involves the species moving into or inhabiting an anthropogenic landscape or space and the development of a “two-way partnership” with humans. The prey or harvest pathway is operationalized through a human desire or intention of increasing

or optimizing the “yield or predictability” of a particular animal or plant resource and/or by-product. The directed pathway occurs when humans intentionally work to domesticate an animal or plant. The outcome and subsequent archaeological evidence of each pathway can be highly variable depending on the targeted species and goals of the people, including sustained management of wild species versus domestication. Thus, it is key to note that none of these pathways guarantees an outcome of domestication. As noted by Larson and Fuller (2014: 130), the commensal and prey or harvest pathways were not intended to pursue domestication, and when domestication was a result it was because “humans became entangled with these species as the relationship between them, and the human role in their survival and reproduction intensified.”

In keeping with Zeder (2015: 3193), “it is more productive to concentrate on the contexts and processes that shape behaviors involved in management, domestication, and agriculture and the evolutionary progression between them.” Therefore, the distinction between the management and domestication of an animal lies in archaeologically identifying evidence of a relationship predicated exclusively on increasing resource output versus mutualistic behaviors between humans and animals, necessitating multi-scalar and often interdisciplinary research agendas and documentation. Based on Zeder (2006, 2015) and Larson and Fuller (2014), Table 6.1 summarizes approaches to the archaeological documentation of animal domestication. This summary is not intended to be exhaustive, but rather to highlight approaches that cross-cut taxa, geographic regions, and cultures through time. Multi-marker, interdisciplinary approaches to the study of domestic and managed animals are essential to “achieving the full potential of domestication research” worldwide (Zeder 2015: 3197). The methods and challenges highlighted in the table are applicable to Caribbean studies of animal “domestication.”

Guinea pigs and hutias: case studies in Ceramic Age animal management

In the New World, Mesoamerica and South America were the centers of early animal domestication, including camelids, turkeys, Muscovy ducks, and guinea pigs. Domesticated at approximately 7000 BC, camelids of the Andean region of South America (i.e., alpacas and llamas) are the oldest known domestic livestock in the New World (Bruford et al. 2003; Mengoni Goñalons and Yacobaccio 2006). The South Mexican domestic turkey (*Meleagris gallopavo gallopavo*) was domestic by AD 180 in Mexico, and genetic evidence also suggests an independent domestication of turkey in southwestern North America around AD 200 (Speller et al. 2010; Thornton et al. 2012). Muscovy ducks were domesticated in southern Peru during the first century AD, were then introduced into Ecuador and elsewhere in South America, and then eventually transported into Central America sometime after AD 700 (Stahl 2005). Guinea pigs were domesticated in the Andean

Table 6.1 Summary of approaches to archaeological documentation of domestic animals based on Zeder (2006, 2015) and Larson and Fuller (2014)

<i>Evidence</i>	<i>Examples</i>	<i>Method(s) of documentation</i>	<i>Methodological challenges</i>
Physical or morphological markers	Changes in overall animal size or particular elements	Comparative morphometrics	Taphonomic variability in bone preservation and degrees of completeness; accounting for geographic and environmental influenced variability in animal size; identifying sexual dimorphism; distinguishing genetic versus plastic morphological variation; standardization in data collection
Physical or morphological markers	Changes in overall animal size or particular elements	Genetic analyses; identification of genes linked to phenotypic expression	Bone preservation, aDNA extraction, identifying mutations, demonstrating genetic and phenotypic links
Genetic profiles	Differences in genetic makeup, including mutations, reductions in gene flow	Genetic analyses	Identifying evidence of bidirectional gene flow between wild and domestic species (e.g., introgressive capture)
Demographic profiles	Sex and age of death patterning	Identification of sex and age markers	Taphonomic variability in bone preservation and degrees of completeness; identifying sexual dimorphism; knowledge of taxa-specific patterns of epiphyseal fusion and age markers
Zoogeographical distribution	Anthropogenic animal translocation	Specimen identification, chronometric control	Accuracy of specimen identifications, solid knowledge of taxa's natural geographic distribution through time
Supplementary data	Remains of corrals or pens; concentrations of preserved animal waste; iconographic art	Various techniques of archaeological observation and documentation	Conditions of preservation
Multi-marker datasets	All of the above	All of the above	All of the above

highlands, a process which may have started as early as 5000 BC with domestication by roughly 2500 BC (Wing 1986). Later, they were introduced to other regions of the Andes (see Stahl 2008). It is not known if domesticated guinea pigs found elsewhere in the Andes, particularly Colombia where wild and domesticated species coexisted (see Martínez-Polanco 2016), originated from the Peruvian highlands or were domesticated independently (see Lord 2017). From a biological perspective, there are no records of animal domestication originating in the Caribbean islands.

Domestic guinea pigs (Cavia porcellus)

Based on archaeological and chronometric evidence, domestic guinea pigs appear to have been first introduced to the Caribbean sometime shortly after AD 600, beginning with Puerto Rico and into the Lesser Antilles no later than AD 1000 (LeFebvre and deFrance 2014) (Figure 6.1). In terms of manageability, domestic guinea pigs would have been an ideal import given their small size for ease of transport and tame nature. According to the Peruvian Institute of Agronomy and Industrial Agriculture (Instituto Nacional de Investigación Agraria y Agronidustrial (INIAA) 1992), domestic guinea pigs are small, generally docile rodents with an average weight of 1 kg and an average life span of four to five years. Female guinea pigs are capable of reproduction by two to three months of age, and may produce between two to five offspring per litter. In terms of feeding behavior and shelter requirements, guinea pigs are able to consume a diversity of leafy vegetables, and are easily cared for in small pens or in larger contained spaces (i.e., house rooms).

Within Caribbean archaeology, domestic guinea pigs have long been a topic of study, with the first report of identified remains made in 1968 by Elizabeth Wing from the Mill Reef site on Antigua (Wing et al. 1968). Subsequently, over the past 50 years guinea pig remains have been identified from Greater and Lesser Antillean sites (see Newsom and Wing 2004; Wing 2001, 2008), with the most abundant remains recovered from six sites on Puerto Rico (LeFebvre and deFrance 2014). Overall, guinea pig remains identified at later Ceramic Age sites are by far less abundant in terms of number of specimens, weight, and individual animals represented compared to other commonly identified terrestrial mammals (e.g., rice rats (*Oryzomynini*), hutias, agoutis). In total, 218 guinea pig remains have been identified and reported from 18 Ceramic Age sites on 10 Caribbean islands thus far (LeFebvre and deFrance 2014).

Suggestions concerning the cultural importance of domestic guinea pigs in Caribbean pre-Columbian history include interpretations of dietary contribution and biogeography (e.g., Wing 2001, 2008), signifiers of possible ritual activity and/or socially circumscribed access as high status food (e.g., Curet and Pestle 2010), as well as possible links to expression of identity or social interactions (e.g., LeFebvre and deFrance 2014). These interpretations are not necessarily mutually exclusive; therefore, archaeological evidence of guinea pig access, use, and/or consumption is important to how we study the

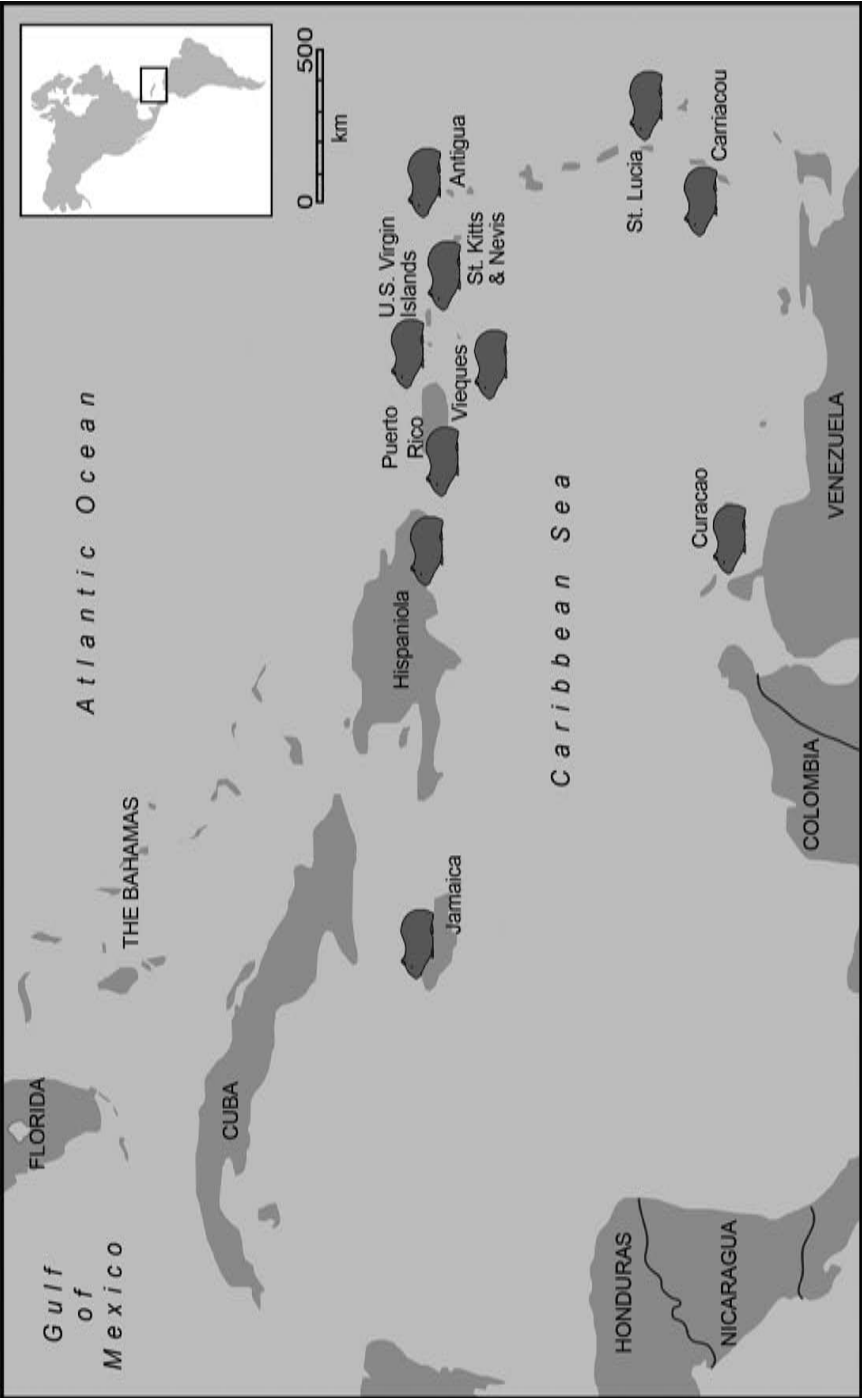


Figure 6.1 Islands with guinea pig remains. (Produced by S. Duser).

managerial relationship between people and guinea pigs, and by extension other animals (e.g., agouti, opossum, armadillo (Giovas et al. 2016; Wing 2008)).

If guinea pigs contributed to everyday subsistence needs, ritual activities, and social interactions across different groups of people, how might we archaeologically document the motivations and activities that facilitated such multi-faceted mutualistic interactions? We suggest three starting points. A first step is to confirm the presence of *Cavia porcellus* versus wild guinea pig taxa (e.g., *Cavia tschudii*, *Cavia aperea*) at Caribbean sites. The identification of *C. porcellus* is typically based on morphological identifications. Recently, Kimura et al. (2016) confirmed the presence of *C. porcellus* specimens with a probable Colombian origin from Puerto Rico and the Grenadine island of Carriacou through an ancient DNA pilot study on guinea pig remains. Following this initial genetic study, Next Generation Sequencing of archaeological and modern guinea pig remains from Caribbean and Andean sites has further elucidated the genetic relationships between guinea pig specimens across different Caribbean islands and the South American mainland. Thus far, results show that guinea pigs were introduced to the Greater Antilles (e.g., Puerto Rico) and Lesser Antilles (e.g., Carriacou) at least two different times and through different translocation events indicating sustained interaction networks with the South American mainland (Lord et al. 2018).

Second, a major tenet of domestic animal control is providing or supervising diet. Isotopic studies of guinea pig diet across different sites and islands are necessary in order to gauge possible parameters of diet control. Although guinea pigs require neither dedicated infrastructure nor significant labor input, genetic and isotopic studies will help to better understand whether an articulation of farming activities existed along with guinea pig rearing. Furthermore, isotopic studies of animal provenance and movement through time will help to reveal patterns in inter-island movement of guinea pigs and how this was integrated within larger networks of interaction.

Third, we recommend (zoo)archaeologists continue to carefully explore and scrutinize a range of evidence, including the archaeological contexts containing guinea pig remains and associated artifacts. Most commonly recovered from midden contexts, Wing (2001) and Newsom and Wing (2004: 205) argue that if guinea pigs were utilized in ritualistic activities, we should not expect midden to be the primary context of deposition (see also deFrance 2010; LeFebvre and deFrance 2014). However, the recovery of guinea pig remains in middens does not indicate that these animals did not serve supra-culinary purposes as well. For example, the recovery of guinea pigs remains in association with ball courts at the Jácenas site on Puerto Rico does not necessarily indicate ritual use, but might indicate a high status food (DuChemin 2013). We are simply advocating for continued scrutiny of archaeological contexts, direct dating of guinea pig specimens, and integration with non-faunal artifact categories as premises for empirically based arguments of guinea pig use and significance (e.g., Carlson 2008;

deFrance 2010; DuChemin et al. 2010; Wing 2008). Likewise, ethnohistoric and historically based accounts of guinea pigs must continue to be used critically because exact details of these accounts often cannot be correlated with the archaeological evidence (e.g., Miller 1929; Rimoli [1978] in Newsom and Wing 2004: 205).

Hutias (*Capromyidae*, *Capromys spp.*, *Geocapromys spp.*, *Isolobodon portoricensis*, *Plagiodontia spp.*)

With high rates of island endemism, hutias are the most abundant and taxonomically diverse terrestrial mammals native to the Greater Antilles and The Bahamas (Pruna Goodgall 2012), e.g., four subfamilies composed of at least 45 reported extinct and extant species (Woods et al. 2001). Across the Greater Antilles, The Bahamas, and Turks & Caicos Islands, hutias have been hunted and consumed by people since the pre-Ceramic or pre-Arawak era (e.g., Colten et al. 2009; Colten and Worthington 2014) through the Ceramic Age (Colten et al. 2017) (e.g., LeFebvre 2015; Newsom and Wing 2004), and they continue to be hunted today on Cuba and Jamaica (e.g., Borroto-Páez and Ramos García 2012; www.iucnredlist.org/details/9001/0). Ethnohistoric records describe the use of dogs by the *Taíno* of Hispaniola to help hunt and capture hutias and the construction of corrals to contain them (Lovén 2010: 434, 437–438).

As described by Borroto-Páez and Woods (2012), hutia can be considered a small-sized rodent weighing approximately 5 kg, although some taxa can reach up to 8 kg (e.g., *Capromys pilorides* on Cuba). Hutia are generally nocturnal and inhabit a diversity of environments and ecosystems, including coastal and brackish aquatic settings, hardwood forests, pine forests, both upland and lowland areas, and anthropogenic environments. Also, hutia are herbivores and readily consume a variety of flora, with preferences for bark, foliage, fruits, as well as cultivated plants (Borroto-Páez and Woods 2012). Studies of modern captive hutia (e.g., *Capromys pilorides*, *Geocapromys brownii*, *Geocapromys ingrahami*, *Plagiodontia aedium*) generally exhibit a broad dietary palate and that a one by two meter space is adequate for a pair of mates and their offspring to live (Eisenberg and Woods 2012).

Within Capromyidae, the most commonly identified hutia taxa in the archaeological record are *Capromys* species in Cuba, *Geocapromys* species in Jamaica and The Bahamas, and *Isolobodon portoricensis* in Hispaniola, Puerto Rico, Vieques Island, and various Virgin Islands (Wing 2001: 490) (Figure 6.2). Zooarchaeological research across the Greater Antilles has demonstrated geographic patterns of hutia exploitation during the Ceramic Age. The patterns are linked with broader trends in island biogeography and terrestrial animal distribution, where larger islands have a greater taxonomic diversity of hutia (e.g., Cuba with 28 extant and extinct hutia taxa (Borroto-Páez and Ramos García 2012), and smaller islands have significantly fewer (e.g., only one species in The Bahamas (Jordan 2012).

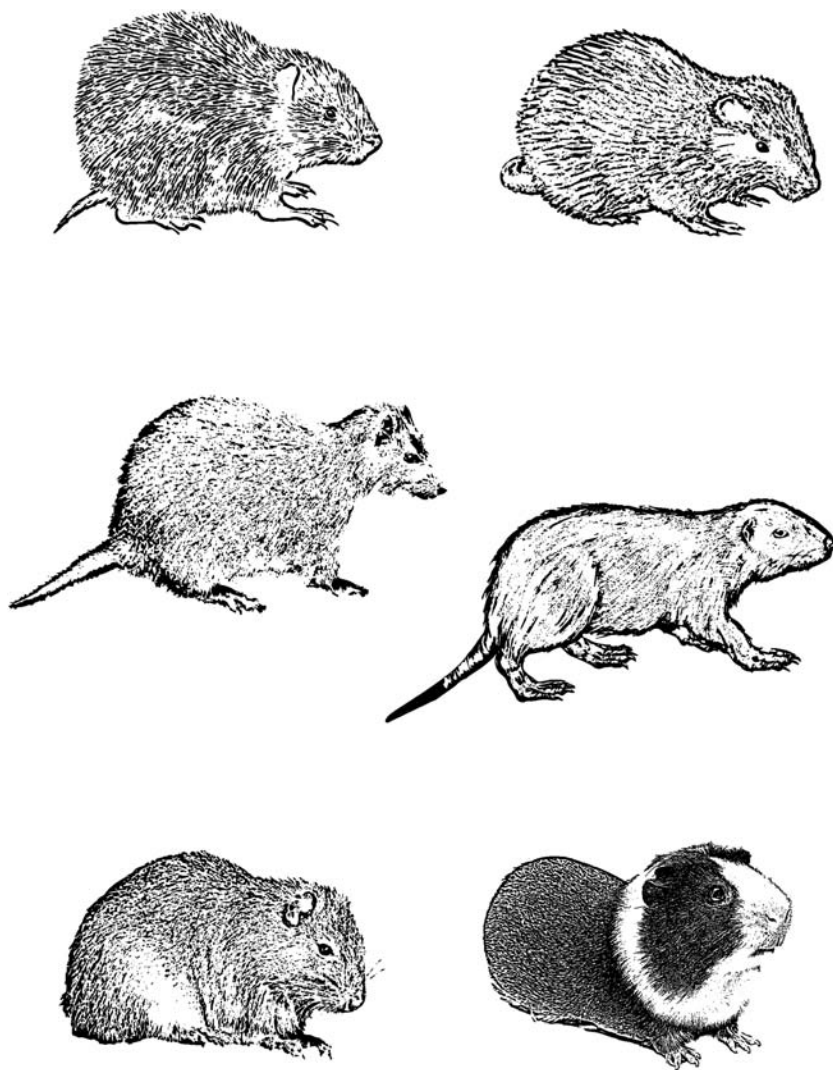


Figure 6.2 Common hutia and guinea pig species that occur on Caribbean sites (Top row: *Isolobodon portoricensis*, *Geocapromys brownii*; Middle row: *Capromys pilorides*, *Capromys plagiodontia*; Bottom row: *Geocapromys ingrahami*, *Cavia porcellus*). (Produced by S. Duser).

Endemic to Jamaica, zooarchaeological evidence suggests that Jamaican hutia (*Geocapromys brownii*) was the preferred terrestrial source of meat. Previous studies suggest that Jamaican hutia were more readily captured and consumed at inland sites (e.g., Wing 2001, 2008); however, recent excavations at the Bengal site located near the Rio Bueno Bay have revealed

a significant quantity of hutia remains, that will be the focus of future study (Angus Mol and Hayley Mickelburgh, personal communication 2017). On Cuba, the Cuban hutia (*Capromys pilorides*) is among the most common archaeologically identified hutia taxa through time, although Colten and Worthington (2014) recently reported multiple hutia taxa (e.g., *Geocapromys columbianus*, *Mesocapromys nanus*, and *Mysateles prehensilis*) present with the Archaic Age faunal assemblage from the site of Vega Del Palmar. Endemic to Hispaniola, the so-called Puerto Rican hutia (*Isolobodon portoricensis*) has been identified from at least nine sites outside of Hispaniola, and the Hispaniola hutia (*Plagiodontia aedium*) has been recorded at one site on Puerto Rico (Wing 2012). The only hutia taxa reported from The Bahamas and the Turks & Caicos is the endemic Bahamian hutia (*Geocapromys ingrahami*) (DuChemin 2005; LeFebvre et al. 2018; Wing 2008). Across the Greater Antilles, as well as The Bahamas, Turks & Caicos Island, and Virgin Islands, there are no published records of hutia remains explicitly associated with burials or contexts indicative of ritual hutia use (Wing 2008: 416). One possible exception to this are recently identified Bahamian hutia remains from Lucayan burials recovered from Garden Cave on Eleuthera (LeFebvre et al. 2018).

Some hutia taxa were introduced beyond their natural geographic ranges and native islands. Wing (2001, 2012) suggests that hutia exploitation, consumption, and translocation across the Greater Antilles were likely centered on intentional management strategies. This suggestion is predicated on the view that generally hutias were not exposed to heavy predation prior to human arrival in the islands (e.g., Jordan 2012; Pruna Goodgall 2012); and, therefore, hutia behavior made them susceptible and/or amenable to human exploitation and manipulation. Similar to guinea pig, the small-sized hutia would have been ideal for human transport across land or sea, particularly in canoes. Although endemic to Hispaniola (Morgan and Woods 1986), Ceramic Age zooarchaeological records indicate that Puerto Rican hutia was specifically selected for and translocated eastward to Puerto Rico, Vieques, and the Virgin Islands (Garner 2001; Wing 2012). As a result, Puerto Rican hutias had the greatest geographic breadth of all hutia species (Flemming and MacPhee 1999; Pruna Goodgall 2012; Woods et al. 2001). The Puerto Rican hutia is the most commonly identified hutia at Ceramic Age sites on Puerto Rico and nearby islands (deFrance and Newsom 2005).

Native to The Bahamas, archaeological Bahamian hutia remains have been reported across the region. They were also translocated beyond their natural geographic range into the Turks & Caicos, including Middle Caicos and Providenciales. On Providenciales, DuChemin (2005) reports a large concentration of Bahamian hutia remains (*Geocapromys ingrahami*) at the later Ceramic Age site of Palmetto Junction (cal AD 1425–1450), indicating intentional translocation and introduction by Lucayan groups. Recent morphological and isotopic analyses of Bahamian hutia remains from Palmetto Junction suggest that the hutia at Palmetto Junction were possibly managed

through artificial selection and dietary supplementation (LeFebvre et al. 2017, 2018).

In her 2008 synthesis of domestic and likely managed animals of the Caribbean, Wing includes a focus on Jamaican hutia and Puerto Rican hutia specifically. Wing (2008: 406, 407) describes hutias, in addition to other taxa, as “tame” and likens their pre-Columbian management to “pet-keeping,” suggesting a foundation for “incipient domestication and maintenance of tame animals in the West Indies.” Wing references Wilkins’s (2001) findings that the dietary and reproductive needs of Jamaican hutia are not amenable to captive management and, therefore, argues that in the past Jamaican hutia were not captive and most readily and efficiently obtained in large quantities through hunting. Wing asserts that the anthropogenic distribution of Puerto Rican hutia, coupled with ethnohistoric descriptions of corrals specifically for hutia, is evidence of organized transportation and management of the taxa. Ultimately, Wing (2008: 421) argues that although Puerto Rican hutias were captive during the Ceramic Age, they were not domesticated “in the strict sense though they might eventually have become domesticated had [the] trajectory not been interrupted in 1492.”

As defined by Russell (2012: 209), taming of animals is an:

[a]lteration in the human-animal relationship with a particular animal that does not have lasting effects through succeeding generations, whereas domestication involves a long-term change in relations beyond the lifetime of a single animal that often results in morphological and behavioral change.

Moreover, while most domestic animals are considered to be tame, not all tame animals are domestic. We argue that this distinction is critical, particularly in a region such as the Caribbean where currently there is no evidence to suggest that native animals achieved domesticated status.

Following Wing (2008) and LeFebvre et al. (2017, 2018), if translocated Puerto Rican and Bahamian hutia remains are examples of management or taming with a possible trajectory toward domestication in the Greater Antilles and the Bahama archipelago (including The Bahamas and the Turks & Caicos Islands), how might we recognize and archaeologically document approaches to hutia management across different species (and life histories), archaeological sites, and islands? For instance, Reynolds et al. (1953) report size discrepancies (i.e., larger, smaller) found among Puerto Rican hutia mandible specimens recovered from “kitchen midden” contexts in Hispaniola and Puerto Rico, and suggest that human translocations of the taxa may have contributed to size variance. LeFebvre et al. (2018) make a similar suggestion that human selection and management of translocated Bahamian hutia may have resulted in larger individuals on Providenciales. Curet and Pestle (2010) argue that hutia remains may be over-represented in terms of edible meat calculations in comparison to other animals at the Tibes

ceremonial site in Puerto Rico. The authors state that this is probably because hutia “were likely to have been tended, and not foraged,” and further suggest that abundances of Puerto Rican hutia may represent elite-provisioned food for large scale consumption (Curet and Pestle 2010: 15, 16). At the En Bas Saline site in northeastern Hispaniola, LeFebvre (2015) suggests that Puerto Rican hutias were widely accessible across hierarchically stratified people, while Deagan (2004) demonstrates that hutias may have also been a preferred food-stuff among elite members of the community.

Moving forward, we call for multi-scalar and disciplinary studies of hutia exploitation (e.g., Kamenov 2016). Like guinea pig, genetic studies confirming various hutia identifications are important, especially given that post cranial hutia remains are difficult to distinguish between taxa (Colten and Worthington 2014). There are also appreciable size differences between individuals ostensibly of the same species, for example Puerto Rican hutia (Reynolds et al. 1953) and Bahamian hutia (LeFebvre et al. 2018), and many questions remain about Capromyidae phylogeny (Kilpatrick et al. 2012; Upham and Borroto-Páez 2017; Woods et al. 2001). The role in food provisioning and taming hutias is also in need of increased study, as well as patterns and occurrences of hutia anthropogenic translocations (e.g., LeFebvre et al. 2017, 2018). Such studies will provide a basis for identifying possible evidence of long-term changes among hutia populations indicative of possible human selection or influence.

The archaeology of domestic and managed animals in the Caribbean

The archaeology of domestic animals is both theoretically and analytically complex, but also holds great value in helping to produce a holistic understanding of past animal management, taming, or domestication. In the Greater Antilles, The Bahamas, and Turks & Caicos, continued research regarding patterns of guinea pig and hutia use and significance among Ceramic Age people will shed light on how animal management influenced broader patterns of subsistence and political economy, including farming, fishing, hunting, and networks of interaction. In addition, human relationships with domestic dogs as well as other taxa traditionally considered to possibly be tame (e.g., agouti, opossum, armadillo) are the focus of current inter-disciplinary studies within the Caribbean (e.g., Giovas 2017; Giovas et al. 2016; Laffoon et al. 2015, 2017; Plomp 2011).

As discussed, management or tameness is not necessarily synonymous with a pathway to domestication. If domestication of hutias or other fauna was a goal during the later Ceramic Age, it is yet to be demonstrated conclusively via genetic or morphometric data. In terms of social motivations behind hutia and guinea pig management and translocations, many questions remain, including why Puerto Rican hutias were translocated so widely compared to other available hutia taxa on Hispaniola (e.g., *Plagiodontia* sp.).

For guinea pigs, why is their island distribution so variable? Why is the overall number of guinea pig remains identified in the archaeological record so low compared to other managed or wild translocated mammalian taxa? Archaeologists more commonly consider these distributions across and between islands as natural or taphonomic phenomena with less attention on the social reasons for the variable distributions of these animals (see LeFebvre and deFrance 2014). Also, how integrated, or not, were hutia and guinea pig exploitation? What were the biological, environmental, and cultural challenges of managing guinea pigs and hutias beyond their native habitats (e.g., Newsom and Wing 2004: 206–208; Wing 2001, 2008)? Finally, for hutias, guinea pigs, and other taxa, there is a lack of supplementary archaeological evidence of captivity such as dung concentrations and remains of corrals or pens due to lack of preservation, highlighting the taphonomic challenges of studying possible animal management strategies in the region. Moreover, these animals appear to have been used almost exclusively for meat; neither provided renewable products over their lifetime that resulted in tangible evidence of animal products. Although both their skins and bones could have been used, there is no substantiated archaeological evidence for the modification or use of either. Finally, beyond their physical remains, the ability to transport, manage, and display these animals may also have conveyed social meaning that is not evident in the archaeological record (see also LeFebvre and deFrance 2014).

We agree with Zeder's (2015) perspective and believe that a focus on the social and environmental contexts of animal management should be at the fore of "domestication" studies. Based on archaeological evidence thus far, we assert that animal management in the Caribbean most likely followed the commensal pathway and/or the prey or harvest pathway, but with variable trajectories and outcomes tied to environmental and cultural heterogeneity among and between islands. A commensal pathway would have necessitated a progressive relationship between specific taxa (e.g., hutias, agouti, etc.) and humans, where of their own volition (or natural inclination) hutias and other small mammals were attracted to and repeatedly frequented anthropogenic landscapes first. Later interactions leading to a commensal relationship or partnership with humans may have, in some cases, provided a baseline for future domestication (Larson and Fuller 2014: 117). Thus, archaeological studies and models of commensal human-animal relationships must allow for recognition of animal agency in the initiation of management and domestication (Larson and Fuller 2014), despite the archaeological elusiveness of this relationship.

A prey or harvest pathway would have involved intentional human action to influence the predictability of animal availability and abundance, resulting in efficient resource management (Larson and Fuller 2014). In the case of hutias, and Puerto Rican and Bahamian hutias in particular, their intentional translocation to new islands and variable habitats necessitated forethought regarding successful transportation, introduction, and establishment. Communication regarding knowledge about how to care for and encourage

reproduction would have been required between and among different groups of people interacting across islands. While the nature of hutia management, especially among translocated populations, is unclear in terms of possible shelter, diet, and reproductive management or selection, we argue that chronometric, site-specific, and/or taxa-specific studies will provide a foundation for more robust comparisons across different sites and islands, helping to elucidate the scope, trajectory, and diversity of hutia exploitation and management (e.g., hunting versus taming).

To this end, we propose that garden hunting provides a model for how Ceramic Age farmers may have approached or initiated commensal animal management and/or a prey pathway toward incipient domestication. The use of garden hunting in the present and past as a strategy for attracting and exploiting fauna has been well documented in the Neotropics (e.g., Emery 2003; Redford and Robinson 1987; Stahl 1996). In a seminal article, Linares (1976) examined the question of animal domestication in the Neotropics using her analysis of faunal remains from the Panamanian site of Cerro Brujo. Linares found that over 80% of the MNI were from three small mammals: the agouti, paca, and armadillo. Although deer and peccary occur in the site vicinity, Linares interpreted the abundance of small mammals as an indication that “garden hunting” was a form of animal tending in the Neotropics that was preferable to animal domestication and that it resulted in a much higher biomass of animal meat than natural conditions. Linares’s concept of garden hunting also expanded the subsistence role of women, because taking animals in cultivated fields and house gardens was akin to collection vegetable or maritime foraging. It also required a relatively unspecialized tool kit.

We acknowledge that the people, cultures, and environmental conditions of the Caribbean and Panama were different, but that much like Panama, the farming populations in the Caribbean relied on house gardens, cultivated fields, and terraces. In terms of diet, cleared fields and gardens of tropical fruits, root crops, and maize would have been attractive to endemic and introduced populations of hutias as well as to domestic guinea pigs. Therefore, also like Panama, a Caribbean system of garden hunting may have prevailed, providing the environmental and social infrastructure to efficiently and effectively engage in opportunistic or directed animal management and procurement. Garden hunting may have allowed for enhanced access to desired or targeted animals, thus leading to patterns of increased prey availability that we would expect for commensal and prey pathways of management, possibly leading toward domestication. Unfortunately, no structural evidence of corrals or pens has been discovered, but garden hunting would have provided a convenient, close-to-home way to capture and subsequently house animals. Moving forward, in addition to taxa specific studies, there needs to be greater integration of faunal and flora datasets in order to holistically test for, demonstrate, and discuss garden hunting, or other commensal management strategies, in the Caribbean (e.g., Newsom and Wing 2004).

Conclusion

Archaeological evidence shows that Ceramic Age food producing strategies were multi-faceted and variable across groups of people within and between sites, including farming, fishing, hunting, and gathering. Although only two domestic animals were present in the Caribbean during the Ceramic Age, animal management and possibly incipient domestication were, no doubt, important parts of the economic, political, and social life of horticultural farmers. As a result, we do not think a rigid concept of “domestication” provides a broad enough framework for recognizing and studying farmer-animal interactions in the Caribbean region. Rather, a theoretically flexible perspective and methodologically robust approach to animal management strategies will allow more nuanced research designs, inter-disciplinary collaborations, and holistic interpretations similar to those advocated previously (see Larson and Fuller 2014; Zeder et al. 2006; Zeder 2015). Several of the current and suggested research avenues discussed or referenced in this chapter are poised to provide datasets from which to empirically test our suggestions and identify possible signatures of management, taming, and incipient domestication during the Ceramic Age.

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Part III

Caribbean farmers and rock art



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7 Rock art and horticulture in the Caribbean

Icons and symbols of humidity

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Introduction

Rock art in the present context includes pictographs and petroglyphs found on boulders, caves, rock shelters and open-air formations, as well as the portable sculptures known as three pointers. These types of visual expression have been produced in the circum-Caribbean for an estimated 7,500 years before European contact, with their characteristics (e.g., numbers, design motifs) unequally distributed across time and geography (see Hayward et al. 2009a). Archaic groups, who were experimenting with cultivation and ceramics, executed carved and painted images on stationary rock surfaces, in contrast to the succeeding Early Ceramic Saladoid fully horticultural and ceramic populations, who did not. Rock art in this form is not evident until the end of the Early Ceramic AD 200–300, when it reaches its widest distribution and highest degree of elaboration during the Late Ceramic, AD 600 to 1500.

Despite this apparent lag in stationary rock art production among the region's horticultural groups, we nonetheless argue for broad and certain specific linkages between cultivation activities and rock art. Any Archaic, Saladoid or Ostionoid groups engaged in husbanding plants or growing crops were likely aware of the various factors that affected the quality and abundance of these dietary sources, including soil and water conditions. Concern with, or attempted control over, these factors would have been manifested in various conceptual and physical forms. We propose a progressive development involving rock art images from a minimal, if non-existent, expression during the Archaic, to the concrete portable shell/coral/stone three pointers interpreted as promoting soil fertility in the Saladoid, to certain stationary rock art motifs—triangles as representations of three-pointers and anthropomorphs with “crying eyes”—related to water/rain symbolism that imply overt magico-religious attempts at fertility controls in the Ostionoid.

Our study is based in the perspective of “cultural archaeology,” first explicitly defined by Irving Rouse (1992: 176), and developed by others including Donald Lathrap. This involves a systems approach in which no component of culture can be considered a “prime mover” in the cultural materialist sense

where the techno-economy or culture's infra-structure determines the super-structure of society and, in turn, the ideology. In our view, all the components of culture: technology, economy, society and ideology, are equally necessary for its functioning. Cultures represent structures of interacting ideas concerning these components that are transmitted and altered from generation-to-generation via language, imitation (observation) and play. In this chapter, we explore the way indigenous ideas about the tenuous control of environmental variability in the form of rock art, may have interacted with techno-economy and society to sustain horticulture-practicing groups in the Greater Antilles.

Creating the landscape through geometry: Archaic rock art

Humans not only live within physical environments, they transform them via their activities, settlements and structures, including the modification of small- to large-scale rock surfaces. The earliest evidence for such modifications in the Caribbean comes from Cuba, where by 4000 BC (or even earlier at 6000 BC, Divaldo Gutiérrez Calvache, personal communication, 2015) Archaic populations were executing geometric, abstract and stylized figures in primarily pictographic forms, with rock art production continuing well into the Ceramic period. At the end of the Early Ceramic period, agricultural groups from, particularly, Hispaniola initiated a shift in focus to an increased figurative or realistic (anthropomorphic, geometric) content and petroglyph production (Dacal Moure and Rivero de la Calle 1996; Fernández Ortega et al. 2009; Izquierdo Díaz and Rives Pantoja 2010; Linville 2005; Maciques Sánchez 2004).

Although anthropomorphs and zoomorphs are recorded for Archaic rock art sites (Linville 2005: table 5.1), it is the geometric/abstract emphasis that marks the assemblages. The later consist of simple to complex arrangements of curved, parallel, angled and intersecting lines and dots including: circles individual or concentric, spirals, short hatchures or comb-shaped motifs, rectangles, and triangles (Dacal Moure and Rivero de la Calle 1996: color plates 3–4, black and white plates 10–11; Fernández Ortega et al. 2009; Izquierdo Díaz and Rives Pantoja 2010; Linville 2005; Maciques Sánchez 2004). Rules of arrangement can apparently be unstructured as in the case of the “interconnected or random lines” style of pictographs found in Cueva Pluma, Matanzas Province. One image represents a plethora of lines oriented roughly at a 45° angle. They are irregularly spaced with shorter lines crossing the longer ones at right or branching angles or alternatively forming small enclosed, but again irregular, polygonal- or triangular-like figures (Fernández Ortega et al. 2009: fig. 3.3). More structured examples include the off-reproduced developed motif from La Cueva Número Uno, Punta del Este, Isla de la Juventud comprising a nested arrow and triangle with several concentric circles, all within a larger multiple-lined concentric circle (Dacal Moure and Rivero de la Calle 1996: color plate 4).

We suggest that the dichotomy between the predominately schematic and geometric pictographs of the Archaic Cuban populations, and the later more representational forms of their horticultural counterparts, mirrors their respective socio-economic structures. The lack of obvious representational meaning and the repetitive nature of these geometric designs may reflect the egalitarian nature of the island's foraging bands, at least in the beginning (Roe 2005: 218, but see Roe [2011: 520] for later indications of incipient ranking in Archaic artifacts and religious manifestations). As Fischer (1961) pointed out long ago, since geometric motifs are identical and/or interchangeable, and can be replicated at will, either asymmetrically or within the rules of symmetry, they may subconsciously reflect the social interchangeability or equivalence of persons within an egalitarian society. Here everyone (age and gender withstanding) has equal access to all goods and services. That is, if men have more access than women, all men have equal access to each others' goods and services, while, similarly, all women have equal access with other women, and the same for children. Thus these early Cuban pictographs could be a reflection of the social equality of the same-gendered or aged persons within their bands (see also Fernández Ortega et al. 2009: 31–32 and Izquierdo Díaz and Rives Pantoja 2010 on Cuban rock art styles and their associations with such factors as geographical location and level of socioeconomic development).

The modern researcher may view overt geometric and abstract designs in rock art and across other media, from ceramics to textiles, as non-figurative, yet various ethnographic and archaeological examples exist to demonstrate that at least certain images were representational in their original contexts. For instance, Roe (1991) has potentially identified gridded images among the petroglyphs at the large village site of Maisabel on the north coast of Puerto Rico as fish traps, while Dacal Moure and Rivero de la Calle (1996: 37–38) suggest that Cuban Archaic figures in particular cases could be very stylized vegetable elements or animals, as well as astronomical referents.

A possible example of a vegetable element as an observation on nature, or an indication of the importance of plants in the diet, comes from Cueva Ambrosio, Matanza Province. While the human visage from that assemblage is post-Archaic in date (Fernández Ortega et al. 2009: fig. 3.2, lower right), the plant-like design above the head (likely Archaic) may represent a palm tree. Twelve other “leaf-like” designs similar to the one at Cueva Ambrosio have been reported in the literature from the Ramos, Del Pirata and Colón caves in the Caguanes area of the Sancti Spíritus province, all probably associated with preagricultural groups (Guarch 1987: 82, table 7; Izquierdo Díaz and Rives Pantoja 2010: 34–36, 42, 51, 52). Alternatively, Guarch (1987: 80, fig. 24) attributes these leaf-like designs to an end process of stylization of the human figure, in short hand form as skeletal ribs.

If indeed these pictographs depict palm trees or vegetable elements in general, they might reflect early plant manipulation on the part of the island's

hunter-gathers. We know from the current foragers of the Colombian jungle, the Nukak (Politis 2001), and from early sites in Amazonia like Taperinha (Oliver 2001), that palm nuts played, and continue to play, an important role in the subsistence of hunter-gatherers due to the richness of their oils, fats so lacking otherwise in tropical diets. The Nukak do not normally resettle on their former camps where the cast-off palm nuts germinate to form new kernel-bearing trees. This situation creates resource patches in the jungle which they then visit for palm nut collection, thus initiating a form of itinerant tending. Perhaps a comparable process can be inferred for the Archaic Antilles.

Another motif recorded in bold lines at Cueva Ambrosio is a large spiral (Fernández Ortega et al. 2009: fig. 3.2, lower center). It has long been a staple of rock art interpretation that spirals may represent whirlpools or springwater holes (see, for example, Figure 7.1). To utilize world comparative ethnographic analogy, Munn's (1962) research among the forager Walbiri of Australia suggest that many of the geometric spirals or concentric circles may indicate, or mark, water holes so essential for forager collecting and settlement. Spirals and concentric circles become a common motif in agricultural-group associated rock art in the region (Figure 7.1), and as Ordúñez Fernández and Ordúñez Cesar (2014) indicate for Cuban images, continue to carry the same association.

In terms of petroglyphs, Cuban investigators also have recorded incised designs in multiple-replicated grid patterns from Cueva de los Petroglifos, Pinar del Río (Fernández Ortega et al. 2009: fig. 3.4), thus confirming the abstract nature of Archaic rock art locally, in both painted and carved forms. It is significant that while some 90 percent of Cuban pictographs may be Archaic (Dacal Moure and Rivero de la Calle 1996: 36), it is easy to distinguish the later agricultural group-related petroglyphs from them because of the prevailingly anthropomorphic caste of their motifs. As we will outline in the following sections, this more human-centric art form characterizes the Late Ceramic stratified Taíno societies with fully horticultural subsistence bases, which will be more overtly concerned with the magical control of water via rock art.

Similar geometric-only pictographs have been recorded in the formally defined Cueva de Berna style named for the eponymous cave in the Dominican Republic (Atilés Bido 2009: 97–98; López Belando with Hayward 2009: 105, 108–109). That style in La Altagracia Province is C-14 dated to 1800 BC, and like the Cuban Archaic ones, is typified by spirals, concentric circles and linear motifs painted within the natural light boundary. López Belando (with Hayward 2009: 108–109) extends the Cueva de Berna style to two additional cave sites in the Dominican Republic—Cueva las Abejas and Cueva las Manos, Pedernales Province—as well as certain Cuban cave locations including Punta del Este and Ambrosio that were just discussed.

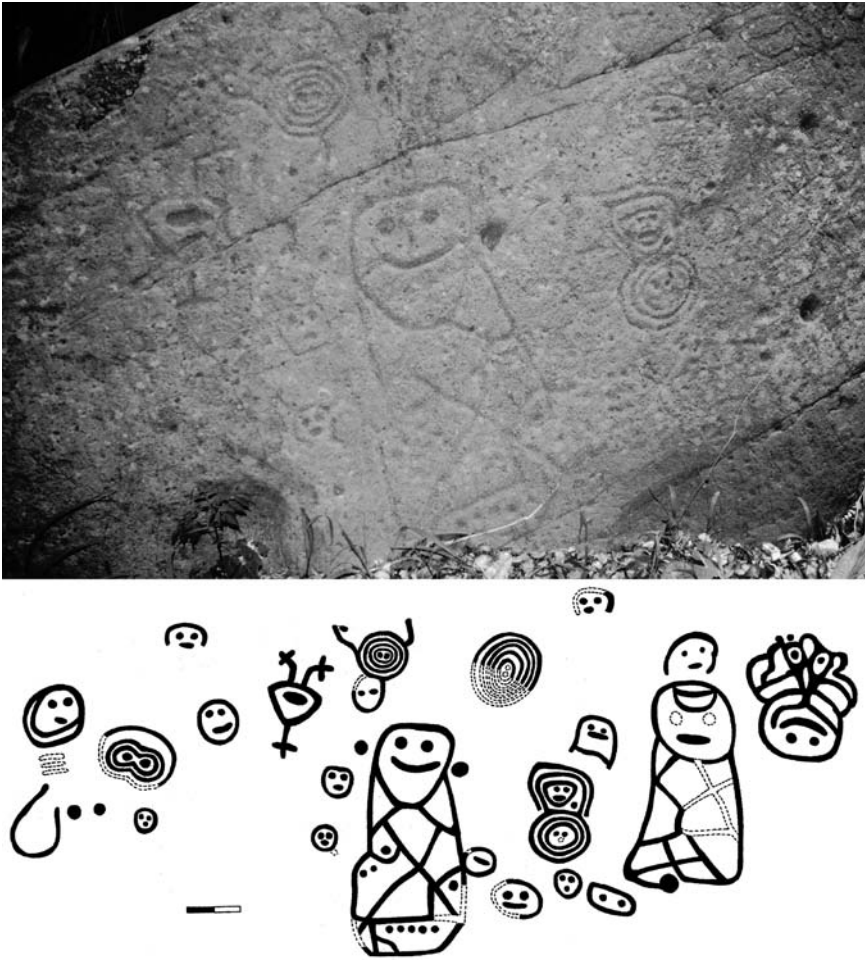


Figure 7.1 Pueblito Carmen, Guayama, Puerto Rico, river boulder petroglyphs with concentric circles common in the region's rock art possibly denoting eddies and whirlpools. Scale 20 cm. (Courtesy P. Roe).

There is even an indication, according to Dávila y Dávila (2003), that the Cueva de las Caritas, on Mona Island to the east between Hispaniola and Puerto Rico, may also date to this time or before (it is close to the Archaic non-rock art cave of Los Caracoles, that C-14 dates to 2380 BC) and is stylistically similar to the Cueva de Berna style. Dávila y Dávila (2003) considered that the three additionally identified rock art cave sites at the time of his study were of later Ceramic Age decoration, a dating which Cooper et al. (2015) have at least partially confirmed.

An illusory paradise: the environmental constraints of horticulture in the Antilles

Migrants into the regions would have encountered inviting land and sea resources for settlement, although not in exactly the same proportions or genera as in their continental homelands. Terrestrial animals in the islands were reduced in numbers and species by comparison (small rodent-like taxa and birds) that nonetheless could, and were, increasingly compensated for as protein dietary sources by moluscan, aquatic reptilian and fish fauna. On land, sandy loams could be found on the well-drained high ground, back from embayments with protective off-shore formations for calm anchorages of the region's watercraft—canoes. First Saladoid and later Ostionoid groups took advantage of these coastal loams for root-crop horticulture, as well as nearby freshwater rivers and mangrove swamps for protein. Abundant humid sub-tropical forests provided opportunities for slash-and-burn gardens, firewood, and animal and bird habitats. Calm breezes and relatively abundant rainfall during the rainy season (particularly on the northern coasts) would have also encouraged horticulture.

But such an inviting picture belies a more tempestuous and unpredictable nature as modern environmental and archaeological studies are revealing. A particularly wet phase during the middle Holocene may have set conditions for the entry of Saladoid ancestral groups from Amazonia into the Lesser Antilles between 3700 and 3000 BC (Siegel et al. 2015). As time passed, drought conditions periodically intruded affecting a broad range of environmental and human conditions, from damaging local vegetation and agriculture to migratory patterns. Sinelli (2015) connects one such drought period from the mid 1000s to the mid 1200s AD to population movements between islands (such as Hispaniola to the Bahamas), while Rives Pantoja et al. (2011) link a specific shift in horticultural groups from eastern to western Cuba around AD 1250, perhaps in response to the same drought cycle that Sinelli mentions. The later authors correlated a number of chronologies from agricultural sites on the island with severe El Niño years, to suggest that they (along with other interrelated climatic factors) played key roles in prehistoric settlement changes. For a comparative modern Cuban example, the intense 1983 El Niño reduced annual rainfall from 25 to 33 percent, and in some places by one half. Further, in Cuba, El Niño years are associated with droughts in the east, counterbalanced with wet conditions in the west, providing a possible reason for the initial entrance of horticultural groups from the east into western provinces around the time just noted. The authors add that, based on their and other's research, climatic extremes/El Niño years produced negative effects for agricultural and human settlements in a widespread area from the southern United States to the Caribbean and northern South America.

Volcanism can be added as a likely low-incidence environmental threat in prehistoric times, but devastating in consequences, to judge by the recent catastrophe on Montserrat. Periodic hurricanes would also have presented a

considerable challenge to Amerindians living in the Caribbean. The high winds and heavy rains associated with hurricanes would have reduced the pole-and-thatch structures of early pre-Columbians to wind-blown debris, flattened their fruit-bearing trees and gardens and caused flooding. Recorded hurricanes, for instance, from Puerto Rico during the 128 years from 1876 to 2004, tally 18 at irregular intervals (the higher the number the more severe)—three tropical storms, four category 1, four category 2, one category 4, and the remaining storms involving multiple categories from 1 to 5 (López Marrero and Villanueva Colón 2006). The particularly devastating category 4 to 5 hurricanes Irma and Maria that struck the northeastern Caribbean in 2017 can be added to the list.

Prehistoric methods to counter high winds are indicated by Samson's (2014) study of Late Ceramic Taíno architecture, where wind-adapted and naturally fortified buildings at the site of El Cabo in eastern Hispaniola (and elsewhere) show the degree to which people reinforced their structures to withstand these environmental assaults. Evidence for flooding in prehistoric times comes from the multi-enclosure/ball court site of Tibes on the south central coast of Puerto Rico (Curet et al. 2015). A major flood event in part of the site is indicated by a layer of unconsolidated sand, silt, clay and poorly sorted gravels, dated to AD 800–1000 underneath the early Ostionoid occupation of AD 1000/1100–1250. The authors point out that major and minor flooding episodes are indicated from other Puerto Rican sites, especially Paseo del Indio and Viví in the northern part of the island, where one such major event at Paseo del Indio, and possibly Viví, coincided with the one at Tibes. In their review of available paleoclimate data, Curet et al. suggest that the cause for the flooding around AD 1000 in various areas of the island was due to unusually elevated humidity resulting in intense precipitation in the form of high energy hurricanes. In short, the idyllic landscape of the Caribbean is less than paradisiacal if one adopts a long-view perspective. This is particularly the case with regard to the regular and steady supply of water so essential for horticultural planning.

Petitjean Roget (2003) has suggested that since much of the rock art in the Antilles is associated with streams or rivers, one of its functions would have been to safe-guard Amerindian access to, and magical control of, that environmentally problematic resource (freshwater) in the prehistoric Caribbean. Certainly, one could make that argument for sites like Fountain Cavern (Big Springs) in semi-arid Anguilla (Crock and Doushou 2015), where the petroglyphs cluster inside one of the few sources of fresh water on the island. Moreover, river boulder sites are one of the major venues for petroglyphic assemblages on large islands like Martinique, Guadeloupe or Puerto Rico. Fernández Ortega et al. (2012) make a similar case for a grouping of nine petroglyph cave sites in the semi-arid Maisí area of the easternmost Guantánamo province of Cuba. They note that all the sites are systematically located along a route of water resources, and, tellingly, the petroglyphs at five sites were carved underneath cave entrances so that any rain would

have fallen on the images. The authors also argue that the horticultural groups, as part of efforts to maintain a safe, continual and equitable source of water, employed ideological measures materialized in rock art that in part reflect specific rain/water symbolism.

Astronomy, cemís, water control and horticulture

As in South America, planning for water control of horticulture among Saladoid and Ostionoid groups may have involved (among other aspects) ethnoastronomy in an attempt to achieve an element of control over the advent of the rains. In Amazonia, shamans watch for the setting of Western culture's identified Pleiades to time the burning of the cut forest and to plant seeds and tubers in the resultant fertile ash. Premature burning would cause plants to wither and die before the rains arrive, while burning too late would cause cuttings to become too wet to burn successfully. In the Antilles, because of the more northern latitude, new stars such as the North Star will be visible and, together with the Pleiades, would be useful in timing the horticultural cycle. In fact, Arrom (1997: 76–77) specifically argues this point for the later Taíno groups. He relies for his inference on the ethnohistoric work of Pané (1999 [1498]), as well as Sebastián Robiou-Lamarche's (1984) study of Taíno astronomy-mythology. Arrom suggests that these groups were able to both identify and understand the movements of the North Star and the constellations Ursa Major and the Pleiades that had direct water-rain referents. Arrom also points out that the mythical figure Anacacuya may have represented the North Star, which was linked in the native mind to the Ursa Major constellation. During its annual cycle, Ursa Major sinks below the horizon from April to August, coinciding with the first rainy season and reappears to signal the second or hurricane season. He further adds that mythic tales of abandoned children near streams who weep bitterly and who are turned into frogs (tears and frogs symbolizing rain) reflect a preoccupation with the rainy season, while Robiou-Lamarche (1984) considers the weeping children to denote the Pleiades.

These types of perceptions run deep within the animistic world view held by current South American lowland tribes, as they likely did among the descendant groups that spread out into the Caribbean region. Various researchers (e.g., Oliver 1998; Stevens-Arroyo 1988) argue for the presence of robust commonalities between the two groupings' cosmological and religious principles that by the late prehistoric period in the Antilles become codified into such concepts as *cemísm*. Oliver (2005: 246–248; 2009: in particular 53–55, 59–63), for instance, considers *cemís* to represent vital forces or numinous powers that could take multiple forms or presences: in natural features and phenomena (trees, smells, floods, hurricanes), as supernatural beings (several principal ones are named in ethnohistorical sources; see Table 7.1 below) and as spirits of the dead. They could manifest themselves to humans, requiring a shaman to perceive their presence and undertake their

physical transformation into a number of objects, including wood, stone and perishable materials. These representations, imbued as they were with *cemí* potency, could interact with humans and other spiritual entities. *Cemís* participated in a network of social relations, and in so doing, they became “persons,” and like human persons they possessed names, deeds, personalities and reputations. *Cemís* were also associated with specific powers such as causing illness, rain, winds and crops to grow, as noted later.

All of these forces just mentioned occupied a multi-tiered cosmos divided into three spacial realms denoted by floating platter or domed worlds (Siegel 1997: fig. 1): Sky World, a positive aerial realm associated with beneficent supernaturals; Earth World or the middle section of humans identified by the particular island people dwelled on (and from whose name their ethnic identification derived); and the Underworld of sub-terrain waters and the dead, located in a deep valley to the west. All these worlds were anchored by the axis mundi of the gigantic Silk Cotton, or *Ceiba* tree, still revered by Afro- and Antillean-derived rural populations. Such a reconstructed cosmology for the Taíno is remarkably similar to a generalized lowland South Amerindian cosmic model (Roe 1982: fig. 3), from which it was probably derived.

Oliver (2005: especially figs. 7.26 and 7.27; Hayward et al. 2009b: 128–132) envisions a more developed view of the cosmos where protohistoric Taíno groups divided the world into two opposing though complementary sets of four domains each. The four primordial domains are: Coaybay the land of the dead, Bagua or ocean, Guanín or Sky, and Ancestors or the progenitors of living humans. The companion domains to these mythical worlds are the ordinary spheres of: Descendants or the existing members of ancestral groups, Turey or Bright Sky of the present, Uniabo or earthly water domain, and Arcabuco or the forests. Oliver considers that this structural arrangement can be seen as a cosmic life cycle passing from a mythic creation time to the present world to death, with death the articulation point between the two sets of domains which sets in motion repeated such cycles.

The universe itself was the product of a whole series of spiraling worlds created and destroyed (Arrom 1997: 73) like the dynamic cosmologies of Central and South America. A correlary of these world views involved a millenarian expectation that the world of the Taíno would itself be destroyed and replaced by other beings (see the account of a cacique, or lord, who had spoken in trance with the *cemí* Yucahuguamá and received the reply that “a clothed people would come who would conquer and kill them and they would die of hunger” (Las Casas [1527: chapter 167] in Griswold 1997: 179), as, indeed, tragically came to pass with the “repeopling” by the Europeans.

Fortunately, numerous mythic fragments, albeit sometimes conflated and confused, were recorded by the early Italian, Catalán and Spanish chroniclers concerning the origin, identity and comportment of the *cemís*’ supernatural beings and forces, who inhabited these realms and whose designation also derived from the Arawak of the Guianas as implying the “sweetness” or

efficacy of shamanic curing (Oliver 2009: 59). Many of them acted as culture heroes creating the elements and life forms of the world such as the ocean, fish, cultigens and the like. Central among all the accounts of such figures and influences was that by the Hieronymite friar Ramón Pané (1999 [1498]) *An Account of the Antiquities of the Indians*, commissioned by Columbus and based on his some two-year village experiences in eastern Hispaniola among the Taíno.

Such religious understanding and structures may have paralleled socio-political development in the region with cemís being relatively undifferentiated animistic spirits during the Saladoid period of largely independent tribal egalitarian village organization, and increasingly ranked during the Ostionoid transition to stratified Chicoid societies and chiefdoms. Arrom (1975), Oliver (1998, 2005) and Stevens-Arroyo (1988), for instance, have all argued for well-developed identifications of certain cemís and their systematic relationships among the protohistoric Taíno cultures of the northern Antilles. Oliver (1998: 110–118) employs ethnographic analogy, ethnohistoric data and a structuralist approach to relate the widespread South American moiety social structural device to the identity and placement of the petroglyph alignment at the main enclosure at Caguana, Puerto Rico. While Oliver (2005) looked at these figures from a largely political point of view (as deceased caciques and cacas), validating their living descendant's power via the public ceremonials, Roe (1993) viewed them as mythic beings from lowland South American narratives, arranged to bestow potency and significance on the proceedings they witnessed and legitimized. In truth, the two points of view are not mutually exclusive, but rather complementary as Roe has pointed out in the comparative study of the Taíno enclosure at Jácana on the south coast (Roe with Roe 2015). Rulers at either site, like their counterparts elsewhere in the prehistoric Americas, can be seen as having appropriated the roles and identities of powerful supernaturals to bolster their coercive power with the moral authority conferred by religious belief. Thus the dead chiefly ancestors/ancestresses of Caguana and Jácana were also representatives of the procreative deities Yucahú and the “Frog Lady” Atabey, representing Yucahú's animal protein of the salt water ocean (fish and aquatic reptiles and mammals) together with his carbohydrate source, manioc, the resulting “sandwich” made fecund by Atabey's fresh waters of fertilizing beneficial rains.

Given our outline of the problematic nature of horticulture in the prehistoric Caribbean, it should be noted that several of the cemís in researcher's reconstructed Taíno ordering, as modified in Table 7.1 below, balanced the constructive/destructive aspect of rain (Oliver 2005: 251). Roe has replaced Oliver's “Order of Fruitfulness” with an “Order of Beneficence” and his “Order of Inversion” with an “Order of Maleficence.” Roe has also added additional characteristics and changed the spelling of the supernaturals to their more traditional mode (see Oliver 2005: table 7.1 for the reworking of Stevens-Arroyo [1988: table 7] and Oliver [1998: III, table 5] that Table 7.1 is based on).

Table 7.1 Dual Taíno Deity Organization (after Oliver 2005: table 7.1 with Roe's modifications in [square brackets])

	<i>Moiety Order of [Beneficence]</i>		<i>Moiety Order of [Maleficence]</i>	
	<i>Deity</i>	<i>Title</i>	<i>Deity</i>	<i>Title</i>
Masculine High Rank	Yúcahu Guamá. . . [etc.]	Lord of Fertility and Abundance [and Master of the Sea and Fishing and Master of Manioc-phallic aspect]	Maquetauire Guayaba	Lord of the Dead [Master of Ghosts, i.e. Opía]
Twin Auxiliary Cemís	Baibrama and Baraguabael	Guardians of commoners, Replenishers of cultigens, fish, animals and plants	Opiyel- guobirán and Cocorote	Guardians of the souls of the dead and night forest; libidinous, picaresque
Feminine High Rank	Attabey Guácar. . . [etc.]	[Lady] of Fecundity and Abundance [Mistress of Fresh Water and Soil Fecundity]	Guabancex	[Lady] of Hurricanes [Mistress of Destructive Wind]
Twin Auxiliary Cemís	Boinayel and Márohu	Guardians of beneficial [calm] rainfall and calm, sunny, bright [dry] weather	Coatrisquie and Guataúba	Harbingers of thunder, violent storms, floods and destructive weather

Consider how these two sides of the dual deity organization also supply the dual aspects of cuisine in the South American lowlands and the Caribbean, with all the nutrients needed for a complete human diet: aquatic and land animal protein coupled with carbohydrate sources such as manioc, maize, sweet potato and marungay. Thus we have the Lord of sunny weather of the dry season (Márohu) balanced with the cloudy weather of the beneficial rainy season (Boinayel) for good horticultural growth. These beneficial deities are ranged against the destructive Lords of excessive winds (Hurricane = Guabancex) and intemperate rains (flooding = Coatrisquie & Guataúba) of damaging weather. By the same token, we have the beneficial “Master of Animals = Fish” fertility = replenishment (Baraguabael) balanced against the Lord of excessive slaughter and death (Opiyel-guobirán). Within this dual system the critical bifurcation occurs between the two apical deities: the male Yucahú and the female Atabey. This pair forms a classic male sky god/female earth goddess union regardless of their exact kinship relationship (the chroniclers called them son and mother, perhaps on

analogy with Christ and the Virgin Mary, whereas their structural relationship is more like consorts).

We next turn to examine the connections between those anthropomorphic complex figures and certain simpler geometric motifs carved on stationary rock surfaces. The link between these anthropomorphic and geometric designs is a class of shell-coral-stone sculpture, a portable form of rock art, which, according to both direct historical ethnographic analogy and chronicle ethnohistory, ties rock art to horticulture in the prehistoric Caribbean.

The three-pointer as link between rock art and horticulture

As indicated in the introduction, rock art production on stationary surfaces is not thought to resume until the end of the Early Ceramic period around AD 200 to 300 for the southern Lesser Antilles according to Sofia Jonsson Marquet's (2009) model and the Late Ceramic period AD 600 for the Greater Antilles, according to Roe's (2005) framework. This hiatus may be related to a process of settling in from the continental Amazonian-Orinocan riverine homeland with little stone to an island setting rich with river boulders, caves and inland rock formations. That the early Saladoid settlers continued to maintain a continental focus is seen in their terrestrial orientation, settlement patterns and mainland fauna depictions in their ceramic art (Roe 1989a, 2009: 219). Therefore, there was, apparently, no Saladoid rock art, much less an association with rock art and their horticultural practices. The production of artifacts like topia or ceramic supports during the Early Ceramic make sense in a stoneless Amazon-Orinoco context, but are unreflective of the possibilities of using Greater Antillean river cobbles. The latter were not put into use until the Late Ceramic (Roe 1989a).

Such cultural material manifestations have led to the characterization of the Caribbean as one made up of dynamic interconnected social networks of mobility and exchange. These systems operated at several levels—pan-regional, regional, local—involved different classes of cultural items and linked groups from the resident Archaic populations to the newly in-migrating Saladoid groups and later largely developed-in-place Ostionoid populations. These interactions formed relationships of various kinds including antagonistic, friendly and competitive. At the pan-regional level, artifact distributions during the Early Ceramic suggest an emphasis on maintaining strong ties to continental homelands. These may have been viewed as necessary or desirable from the perspective of the in-migrating populations to ensure social, economic and demographic viability. The ties lessen or transition to an emphasis on regional networks, local manufacture and island-derived anthropomorphic and zoomorphic images during the Late Ceramic as populations adapt to their new physical and cultural environments (Hofman et al. 2007, 2011; Hofman and Hoogland 2011). With regard to rock art, mainland ties were at first sufficient to integrate communities into a common symbolic and ideological world view, in part outlined in this chapter. After some time, these communities developed

regional and local identities materialized in various forms that now include carved and painted images on stationary rock surfaces.

Over the years, Ostionoid rock art has been interpreted as having various functions, including projecting a concern for factors, like rain, which affect horticulture. We argue that while such concerns are evident in the general placement of the rock art at or near water resources and particular motifs of the Ostionoid, they were also expressed in the Saladoid, albeit in the form of mobile rock art—the three-pointer. While the date and cultural origin of the three-pointers remains under discussion in the literature, examples in the Caribbean are known from archaeological contexts at the very beginning of the Saladoid (Oliver 2009), with production continuing into the period of European contact, encompassing some 2,000 years of cultural continuity. This longevity indicates their clear, critical role in the lives of these groups.

Most of the early three-pointers are small and made from the Queen Conch's columella tip. This gives them their typical concave under surface which will be faithfully transferred to coral and stone examples, as skeuomorphs, down to the end of the prehistoric period. Most are also undecorated or unincised, although one shell example from the site of Maisabel—a large Saladoid to Ostionoid village site on the north coast of Puerto Rico—has a skyward-looking human visage delicately incised into the shell (hinting at the human soul in the gastropod) (Roe 2011: fig. 33.3a).

During this long production period, the three-pointer morphed in shape and materials in consonance with the scale of the societies that reproduced it. The earliest examples are small, derived from their parent shell, and suited for close-up “personal presentation” in a largely unstratified society like that of the Saladoids. By the middle or Pre-Taíno period of the Elenan-Ostionan Ostionoid cultures (and their demographic expansion and incipient rank society development), the three-pointers became much more numerous and were now executed in crude coral and plain medium-sized stone versions (Roe 2011: fig. 33.3b). It would appear that their use has become more utilitarian rather than their earlier function of commenting upon the cultural sophistication of their bearers and their inherent numinous messages. Last, in the Taíno period, with their simple to complex stratified chiefdoms, the three-pointers are transformed into large, barely portable sculpture (Roe 2011: fig. 33.3c). They are intricately and representationally rendered in at least three types (McGinnis 1997), all of which loudly proclaimed their new function as the emblems of the “public power” of their elite holders (the noble ranks and caciques themselves). Meanwhile, smaller and cruder examples continued their public functions in activities such as ball games and in the private horticultural realm among the commoners.

Archaeobotanical research indicates that prehistoric Caribbean groups relied on a range of domesticated and wild plant foods from various tubers to maize whose proportions varied across time and place (Pagán Jiménez 2013). The cognitive component of plant production, we suggest, can be seen in the linkage of one artifact—the three-pointer—and one domesticated

plant—manioc, called yuca by the Taíno. While the functions of three-pointers changed over their long production period, at least one purpose for the smaller examples can be argued from ethnohistorical sources and direct ethnographic analogy—that of magically fomenting horticultural fertility. Three-pointers are the only stone artifacts specifically identified as to cultural function by the chroniclers, and that purpose was to promote crop fertility, particularly manioc (Walker 1997: 82). Pané, for instance notes that: “The stone zemis are of different constructions . . . others have three points, and they believe they cause the yuca to sprout” (1999: 26 [1498]).

On the simple level of analogy, the manioc tuber is long, pointed and distinctly phallic in shape, thus replicating the pointed shape of the triangular three-pointer. In the lowlands of South America, this physical resemblance has not escaped Amerindians, who liken the scraping of the manioc tuber by women to their sexual undulations on their lover’s penis, thus causing men to ejaculate in sexual intercourse. Moreover, in myth manioc is first brought to women by their “aquatic seducer,” a long, phallic-shaped black cayman, sprouting from the tip of its tail (tails being a common Amazonian euphemism for phallus), or actually gushing as ejaculate from the caymanic dragon’s penis in the 1000 BC jungle-inspired Tello Obelisk at the Andean ceremonial center of Chavín de Huántar, Peru (Roe and Roe 2012). Many central Brazilian tribes like the Arawakan Mehinacu still plant their manioc in raised conucos (“ridged fields”) shaped like a cayman’s body, inserting the manioc (or similar cultigens like piqui) into the genital area of the clay cayman while ritually enjoining it to “have sex” with the feminine earth, and thereby multiply the tuber and hence the crop’s yield. Last, in the “form code” of Guianan Caribs (and probably Ostionoids as well), all male implements (weapons, like spears, arrows, sword-clubs, etc.) are long, sharp, solid, dry and hard, in emulation of their penises, while all female instruments are round, hollow, soft and wet (clay for ceramics, baskets, textiles) in emulation of their “somatic geography.” Thus it appears that Antillean peoples associated manioc (yuca) inducing potency with a male cemí spirit, in particular Yucahú, having the three-pointer as at least one of his physical materializations.

The small utilitarian three-pointer stones recovered from midden and field contexts in the Greater Antilles may have their counterparts in the manioc stones of Amazonia (Roe 2011: 533–534). Such an equivalence is reasonable given that is where both manioc and the Taíno’s ancestors originated. From the Canelos Quichua of the Ecuadorian mountains in the northwestern periphery of the Amazon Basin (Whitten 1976: 19) to the Cariban groups (Akawaiyo and Waiwai) of the Guianas in the northeastern periphery (Yde 1965: 30), stones are buried in manioc chacras or gardens to promote the growth of the tuber in an act of widespread imitative magic. In the Greater Antilles, three-pointed stones were buried in the conucos to fulfill the same purpose. Even though the identical goal of soil fertility promotion employing similar objects is indicated in both the prehistoric

Caribbean past and the ethnographic present, it should be pointed out that current Amazonian groups associate this process with the feminine earth realm, while Antillean ones link it with the masculine god of manioc, Yucahú, emulating his very form in an act of male appropriation.

The execution of the three-pointer in petroglyphs in multiple settings

The foregoing discussion provides the necessary cultural background to interpret triangular-shaped designs on stationary rock surfaces as three-pointer representations, and by logical extension the male cemí Yucahú. Three-pointer images are found in diverse settings, from caves and rock shelters to beach rock. Their presence, never common, and variable appearance range from the representational (see Olsen 1973: fig. 3) to the abstract (Atkinson 2009: fig. 4.1e), hinting at the magical control of rains and hence horticultural productivity. If the rains were the product of Yucahú's mother or consort, Atabey, that would explain the ubiquity of the frog position for theri-anthropic humanoids in Greater Antillean rock art, from the petroglyph boulders at the Taíno enclosure sites like Caguana and Jácana (Roe 1993, 2013), to countless cave and river boulder images. After all, when it rains there is a veritable shower of coquis falling from the rain forest canopy to the humid forest floor. The frogs then begin a deafening chorus soon after the downpours, thus becoming icons of the rain and the verdant vegetation that results from the abundant moisture. Their clusters of numerous eggs hint at the progeny such feminine-associated creatures are capable of creating, who even when abandoned by their frog mothers cry out like so many frogs in Taíno myth. So too would many human progeny spring forth from the fecund rains of the Frog Lady Atabey, to whom women prayed for success in childbirth (Rouse 1992: 118).

From whence, then, comes the role for Yucahú? Just as children come from two, so the manioc plants comes from two (in myth and ritual, and via seeds—not all manioc reproduction is vegetative). One is reminded of the perhaps apochryphal story recorded by Pané (1999 [1498]) concerning the hapless Amerindians who knew from the missionaries' strenuous efforts that the Christian sacred objects had powerful amulet-like potency, and therefore in their minds should be as capable of engendering horticultural productivity as the three-pointer. So they stole some of these objects from a Spanish chapel, buried them in the ground and then urinated on them saying "Now they will grow well and yield much fruit" (Arrom 1974: 45–47), as they would have sprinkled the buried three-pointer with their "water." Unfortunately for them what they understood as a pious act was viewed by the Spanish as the height of desecration and sacrilege and they paid for the cultural misunderstanding with their lives. "Later, at the very spot where the images had been buried, unearthed yams [sic: manioc tubers] were said to have grown together in the shape of a cross. This was considered a miracle even by the Taíno" (McGinnis 1997: 92; emendation ours).

In the animistic context already referred to, any piece of portable art like a three-pointer or stationary rock art, whether petroglyph or pictograph, was *cemí* in a general sense, as was their rocky context (rock shelter, cave, river boulder, ball court/enclosure rock alignments), in addition to whatever mythic being or force (usually anthropomorphized) it represented. The chroniclers mentioned that so important was the rain that when a drought occurred, a *cemí* in charge, made of stone or wood, would be petitioned to give them rain or, if the rains were persistent and damaging, to give them sunshine: “They believed these *zemis* gave them water and wind and sun when they had need of them, and likewise children and other things they wanted to have. Some of these were made of wood and others of stone” (Las Casas 1527 in Griswold 1997: 176). Specifically, we also have dual petroglyphs being petitioned to bring rain (Pané 1999: 17 [1498]). Thus a three-pointed object, when it appears in petroglyphic images, may have connoted a powerful *cemí* like *Yucahú*.

Its spatial context in petroglyphic and pictographic assemblages should reinforce such an iconic inference. Roe (2005) points out that we have just such contextual evidence for the importance of three-pointers in stationary and portable rock art forms, and we have it in multiple sites and site types. We begin with the “water gyre” to follow the three-pointer’s journey, from its source in upwelling rivers flowing out of immense caverns such as *Cueva de Mora* in Comerío, thence to rock shelters like *Mural de Zamas* in Jayuya along watersheds, to the joining of terrestrial fresh water with oceanic salt water in the beach rock assemblage of *Maisabel*.

In the huge cave of *Cueva de Mora* near Comerío in the eastern highlands, itself a multi-leveled recapitulation of the three-level Taíno cosmos outlined earlier (Roe 2005: fig. 8.16), we find guardian petroglyphs manning the lower solution tube entrances of the Sub-Aquatic Underworld, (for there is a wet cavern below this dry cave, from which flows a river) to the main chamber or Earth World, festooned with a plethora of life-size and complex pictographs, often wrapped ancestral figures and a series of stylized and anthropomorphic turtles (feminine life icons of First Progenitrixes according to the mythology recorded by Pané, Roe 2011: 519). Then, high above, at the level of the Sky World, in a stalagmite pointed eminence descending from the roof, is a large pictographic three-pointer, viewed front end on, with a dual-lobed headdress (Figure 7.2). The image-maker took advantage of the stalagmite’s volume to give the figure the roundness and pointed shape of a sculptural three-pointer. Significantly in this place of the dead, the human face on the three-pointer is depicted as skeletal, the part-negative image assuming the contours of a skull, with rectangular orbits, gaping mouth and prominent mandible (see Figure 7.2).

A very similar situation to *Cueva La Mora* was recorded at the equally massive *Cueva de la Catedral* in Hatillo, Puerto Rico, by Díaz González (1990). Once again, we had simpler guardian petroglyphs stationed at the entrance to a deep cavern, succeeded by larger and much more complex



Figure 7.2 Cueva de Mora, Comerio, Puerto Rico, frontal view of an anthropomorphic skull-faced three-pointer pictograph. Scale 10 cm. (Courtesy P. Roe).

pictographs peppering the interior (Roe 2009: fig. 15.1). Images of death are also found, as in skull-like visages (Roe 2009: fig. 15.2a–6), inverted faces (Roe 2009: fig. 15.2b–2), and nocturnal (ghost-affiliated) species like bats (Roe 2009: fig. 15.3e–3). Fittingly, these mortal images lead to numerous “mummy bundles” or lozenge-like figures with internal lines (Roe 2009: figs. 15.4i–3, 7, j1–12) and wrapped ancestors (Roe 2009: figs. 15.4i–4–6, i–8) in the deepest recesses of the cave. These pictographs mark the cave as a sacred subterranean place for the internment of the dead since the painted lozenges appear to depict the deceased enfolded in their hammocks. There is even one depiction (Roe 2009: fig. 15.4j–14) which Roe (2009: 227) interprets as a humanoid three-pointer-like image of Yucahú, the last depiction among the wrapped ancestors. Just as the tubers regrow from the eyes in their stalks in the ground, perhaps also humans would find rebirth in this damp, dark and cold place out of the “eggs” of their makeshift shrouds. We will see that juxtaposition of life and death, female and male, in other contexts further down the water gyre to the sea.

As the rivers flow down to the coastal plain, on the flanks of the highest mountain in Puerto Rico, Cerro La Puntita in Jayuya, central-western highlands, we find a series of petroglyph sites involving river boulders like the Mural Azul site (Hernández Llanes and Roe 2015), and then above it, the

rock shelter of Mural de Zamas (Hernández Llanes et al. 2015) along the Zamas River system. Providing a narrative function of the diurnal-nocturnal daily cycle, with solar images to the east and nocturnal (bat and coiled snake) to the west, the central petroglyphs form a complex labyrinthine set of compounded images (Figure 7.3). There we encounter a profiled three-pointer symbol nested within the grouping (Figure 7.3a), as well as a nearly complete interpreted masked dancer with raffia fringe (Figure 7.3b). Such a figure evokes closely similar masked spirit impersonators who dance in the cleared plazas of the circular villages of the Arawakan and Cariban societies of the Upper Xingú on the central Amazon (Roe 1995: fig. 170, Kamayurá).

These cleared circular plazas common in the South American lowlands (Roe 1987), find close parallels in the open, central plazas of the Saladoid villages of Puerto Rico such as Maisabel (Siegel 1997). At first these central spaces frequently served as cemeteries in addition to presumed public functions. During the Ostionoid period, they were at times transformed into stone-lined ball courts, or dance enclosures, with petroglyphs at various sites on the island (Oliver 2005). All throughout that evolution, these public spaces remained as the quintessential masculine display areas for the encircling feminine residential structures in what Roe (1987) has referred to as “Sexed Space.” Many of the three-pointers have been found at enclosures, as have broken circular stone collars, hinting at their function as publicly displayed emblems of the élites sponsoring the activities. Such displays may have had magical connotations of increasing horticultural productivity as well as entertainment. Sacrifices, including human ones, hint at such functions since they involve the transfer of vital life energy and therefore could bridge the three-pointer’s and stone collar’s (the masculine three-pointer = fertility / the feminine stone collar = fecundity) plaza and plant productivity associations.

The possible role of human sacrifice in Taíno horticulture rests on an admittedly conjectural association of cultural elements. However, there is either chronicler or iconographic evidence for each of the elements in the proposed causal chain. First, on analogical grounds abundantly illustrated in related South Amerindian cultures, the shedding of human blood could have been likened to the shower of anticipated rain (or even as the Moche sacrifices illustrate, Bourget 2005, the stopping of excessive El Niño rains and subsequent flooding). Second, we have testimony from Oviedo (cited by Oliver) that “on occasions, a human life could also be at stake and put up for betting ([in the ball game] winners would gain the right to kill the person), as several Spanish captives would find out” (Oliver 2009: 22). That such deaths were, perhaps, a form of human sacrifice to ensure an abundant source of water for the crops is suggested by the Amerindian tendency to invest such deaths with a heavy “semantic weight” that included sympathetic magical connotations, not just a social matter of betting or status aggrandizement.

Here is where the last link in the argument comes in that is congruent with our perspective that water played a central role in Taíno and pre-Taíno

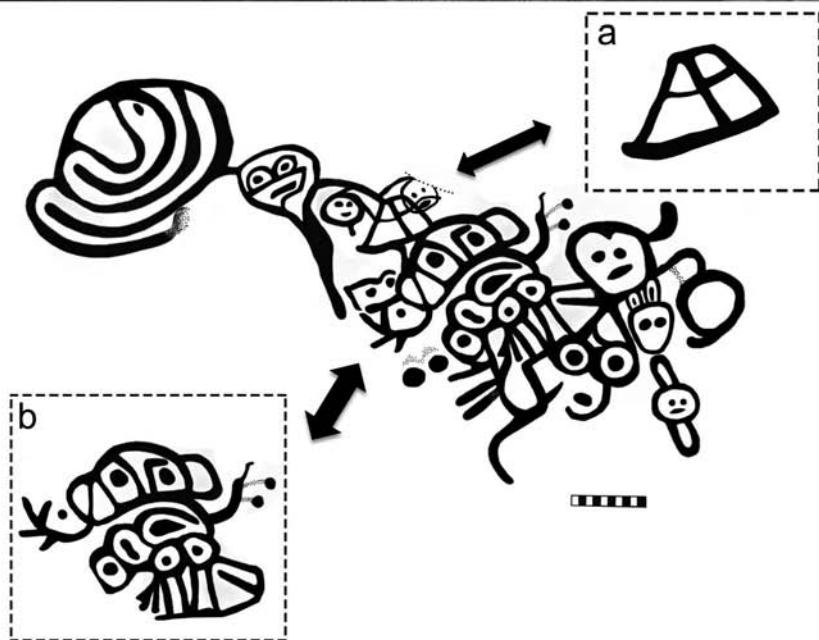


Figure 7.3 Mural de Zamas, Jayuya, Puerto Rico, labyrinthine petroglyph assemblage with coiled snake, a profiled three-pointer (a) masked dancer (b) and assorted facial images. Scale 10 cm. (Courtesy P. Roe).

cultural preoccupations. Roe (2005) has already made the point that such ball parks and dance plazas represent a kind of inversion of the river boulder petroglyphs (water between rocks rather than rocks in water), yet another link in the “water gyre” flowing to the sea. Any view of a flat flooded plaza, the water ponding and glinting on the hard-packed clay, attests to their aquatic connotations. Such associations are reinforced by the imagery carved on the surrounding petroglyphic boulders: fish, aquatic birds like herons and pelicans, and frog-like amphibian-anthropic figures (the major supernaturals/or supernatural-impersonating ancestral caciques and cacas). The persistent association of such plazas with three-pointers is also congruent with our argument. Thus, in addition to the many political implications of the ball-game and dance plazas as reinforcing cacical power with supernatural authority, and providing a setting for political and marital alliances and display, magical acts may also have occurred. Human sacrifices that took place within or near them, particularly with the attendant shedding of the potent red liquid that is blood, could have had a sympathetic or imitative magical function of summoning the rains. Such precipitation was, of course, essential for the horticultural production and its resultant surpluses which were instrumental in supporting these chiefdoms.

We know that in the lowlands of South America many such festivities are tied to the planting/harvesting cycle, and resultant subsistence productivity, where male masked dancers impersonate the relevant spirit beings. The visiting spirits are entertained and fed to encourage their productive/protective functions for human consumption and social continuity. We have elaborate masks referred to by the chroniclers, beginning with Columbus himself, and obvious masks have been depicted in rock art. One striking example is a diamond-shaped pictographic mask from Cueva Hoyo de Sanabe in the Dominican Republic (Atilés Bido 2009: fig. 7.2). Here, at Mural de Zamas, we find a remarkably similar juxtaposition to the Upper Xingú masked ceremonies where the *cemí* is impersonated by a masked raffia-festooned male dancer performing, we assume, in an *areíto* (*areyto*, a ceremonial dance) at an enclosure dance ground associated with a three-pointer pressed against his body (see Figure 7.3b).

Lastly, at the end of the ancestor’s water gyre, in the horizontal bedding planes of the eolinitic formations at the ocean edge of the multi-component Maisabel site, we find petroglyphs pecked into the soft sandstone, in whose lithified former dunes were also recovered Elenan Ostionoid sherds. This association provides the starting point for Roe’s Puerto Rican rock art developmental framework noted earlier (Roe 2005). Amidst the fish and sea turtle aquatic imagery are two representations of a three-pointer. The first is a unique “twisted” or “dual-view” image where a simple frontal face (round head, two dot eyes and a down-turned slash mouth) shows the three-pointer as viewed face-on, that is, looking at the front end of the anthropomorphic sculpture. Further the slightly mis-executed triangular form is depicted as if in profile, complete with a connected “barbell”

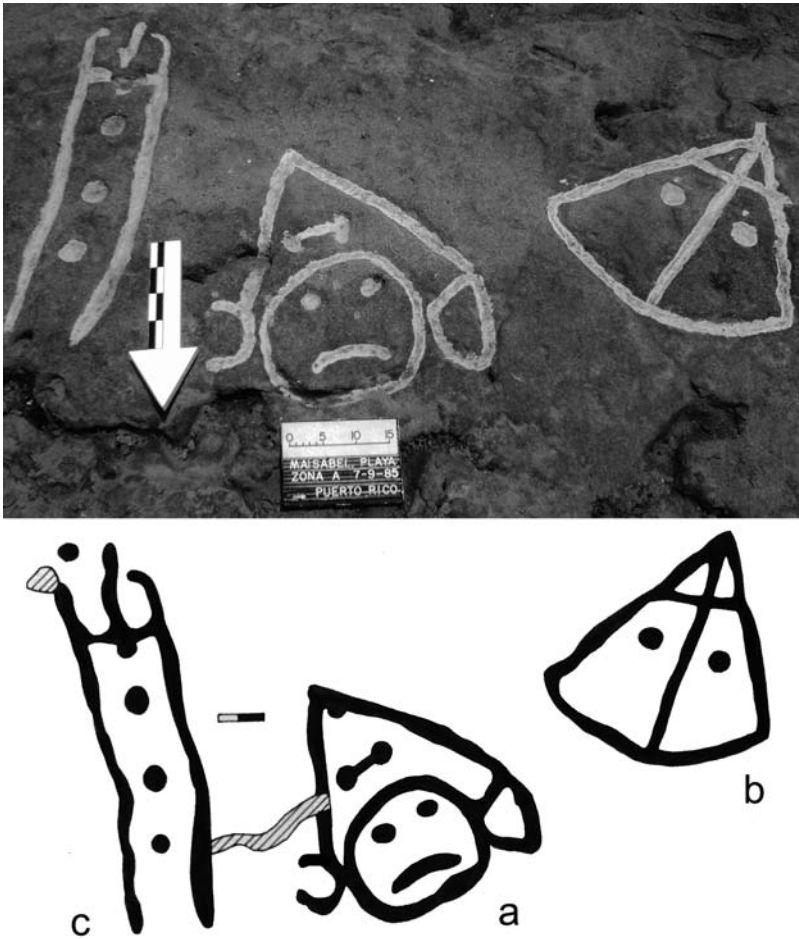


Figure 7.4 Maisabel, Vega Baja, Puerto Rico, petroglyphs, a frontal anthropomorphic three-pointer (a) a profiled three-pointer (b) and headless enclosed body motif (c). Scale 10 cm. (Courtesy P. Roe).

incised element near the apex of the supra-facial point. The second depicts a three-pointer in profile with internal crossed lines and dot design elements (Figure 7.4).

Tears that fall like rain: “weeping” petroglyphs

The other class of rock art which may relate to a magical desire to control rainfall to benefit horticulture in the prehistoric Caribbean is a group of

petroglyphs that appear to be “weeping” or “crying.” That is, they have incised lines descending from their eyes in the manner of tear tracks (Oliver 2005: fig. 7.21). While this may not be the only possible interpretation (similar motifs in South American coastal Peruvian art represent the facial markings of the falcon), it appears plausible from the point of view of analogy. Such an interpretation would also be consonant with other analogical linkages to human-produced “water,” as in the tale already alluded to of the men urinating on a sacred paraphernalia to encourage rain. It is certainly reasonable to argue for the importance of analogy in Amerindian thought, particularly when it comes to the human body and its application as an imported analog to the natural world.

Arrom (1997: 73) has long interpreted such figures, whether they appear as portable art or on stationary rock surfaces, as examples of one of the 12 key *cemís* mentioned in Pané’s account (1999 [1498]: 17). Boinayel is identified as the god of auspicious rains, with his tears emblematic of falling rain, in Arrom’s words the “(Son of Grey Serpent) [who] controls the arrival of the good rains” (1997: 73). He singles out two portable examples: one a free standing wooden *cemí* from Jamaica with prominent tear marks found in a cave in Carpenters Mountains, Jamaica, and an incised stone cobble from Nipe Bay, Cuba in the form of a human face with tears flowing from stylized eyes (Arrom 1997: 73). Boinayel had emerged from the sacred cave Iguanaboina as one of two *cemís*, the other being Márohu. It will be recalled from the foregoing discussion that both these spirits/deities are meteorological in nature, and therefore of interest from the point of view of horticulture: “Márohu (Cloudless) brings back clear skies” (Arrom 1997: 73). “Boinayel [Rain God, Son of Grey (Rainbow) Serpent = Dragon-Roe’s emendations] controls the arrival of the good rains” and is sometimes paired with a twin named Márohu (Arrom 1997: 73). Because the name means cloudless, Arrom (1989: 39) considers Márohu to be the deity of fair weather. If Roe’s relating Grey Serpent to the Rainbow Boa, the feminine snake that arches through the air after rain (Roe 1989b) is tenable, then we can suggest why these two *cemís* were paired as “twins.” Both announce the end of the rains, first the rainbow then the clear, sunny skies that follow. For Amerindians it is always as important to stop the rains magically, as well as to initiate them. Excessive rains can cause flooding, and crop destruction, just as surely as a lack of rain. The chroniclers make the same point for the Taíno (Las Casas 1527 in Griswold 1997: 176).

Yet, such assignments of rock art or other sculptural images to specific supernaturals is always problematic. That is why we prefer to base our arguments largely on analogy using the art historical technique of close visual examination. Oliver (2009: fig. 17) illustrates the differences of interpretation that specific images can elicit when he disregards Arrom’s identification and, instead, relates the teared wooden sculpture from Jamaica to a human shaman or cacique taking cohoba: “The broad tear canals on the

cheeks probably represent the physiological reaction to the cohoba drug.” The tearing as a result of inhaling the hallucinogen seems to us, however, to be improbable since the main reaction to nasal injection is the profuse discharge of mucus (Chagnon 2013: fig. 1.5), not tearing. Yet there is a faint association between the cohoba tables and supporting human figures that have the tear marks, as in the examples from the Dominican Republic (Alegría 1997: fig. 7), the Carpenters Mountain figure already alluded to, as well as another anthropomorphic cohoba table from Jamaica in classic Taíno representational style (Roe 1997: fig. 114). On the other hand, these particular tables could have been dedicated to imploring the relevant *cemí* for rain (Boinyael in Arrom’s identification).

In addition to such depictions of teared figures in wood sculpture, we also have ancestral wrapped figures in pictographs executed with tear-lines from their eyes running down their cheeks from Cueva de Mora, Comerío (Roe 2005: fig. 8.21c), and in petroglyphs from Cibuco (Miner Solá 2002: 55, left), to name just two instances. Additionally, we have a human-like head with tear channels from its eyes petroglyph 17 in the stone alignment at Caguana’s Plaza A in Utuado (Oliver 2005). Significantly for our argument, this monolith is located in the sector of the plaza that corresponds to Uniabo, the earthly water domain (river = fresh water) in Oliver’s (2005: 276–279) idealized reconstruction of the plaza as a microcosm of the Taíno macrocosm, and in opposition to the primordial Bagua (ocean = salt water). While keeping in mind that the precise location of these petroglyphs is open to some doubt given their original ruined context and subsequent restoration (Oliver 1998), Oliver’s treatment is at least detailed, consistent and fairly persuasive. By occupying the axis of the “humid,” especially that of fresh terrestrial water, the “crying” petroglyph 17 reinforces the analogic properties of tears = rain, since rain swells the rivers of the interior and turns the mountain gardens verdant (Figure 7.5).

Moreover, there are at least two instances (one in the Dominican Republic as mentioned in Pané [1999: 17 (1498)] and the other in Cayey, Puerto Rico [Rivera Meléndez 1996]) where paired guardian petroglyphs at the entrance to caves appear to “sweat” as a result of the humidity differential between the cool cave air and the surrounding outside hot atmosphere. These might be relatable to the teared carvings and, in turn, to the bringing of rain/fresh water. The latter association is particularly convincing since the caverns, as well as sink holes, have been formed by the solution of limestone via carbolic acid, and thus often hold subterranean rivers and drowned chambers/pools out of which issue rivulets, as at the Cueva de Mora in Comerío, Puerto Rico. Thus they, and their associated rock art, become linked with fresh water and rain.

If we can make the association between “weeping” figures and rain, this relationship may be as old as the first Saladoid migrants into the islands. This is because “teared” ceramic figures decorating their elaborate pottery have been recovered from the Puerto Rico as well as the Troumassoid

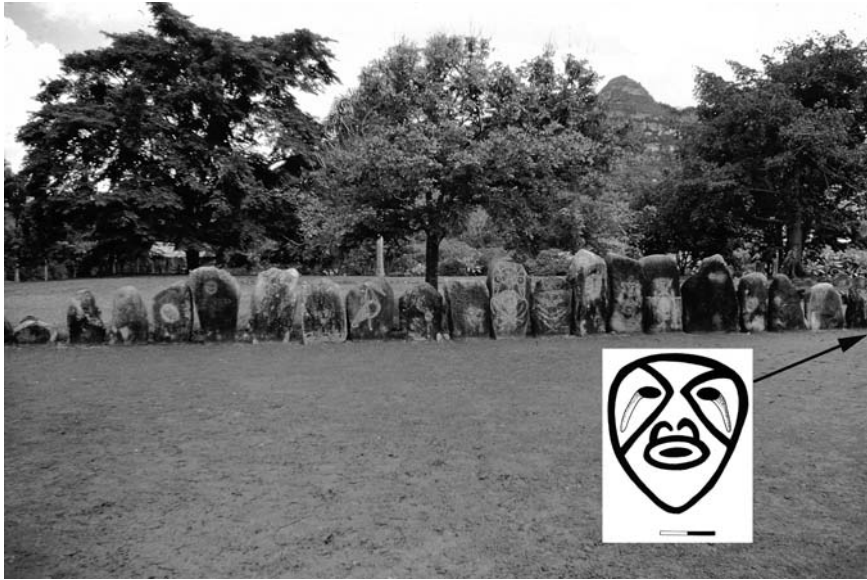


Figure 7.5 Caguana, Utuado, Puerto Rico, panorama of the reconstructed western alignment of petroglyphs at main plaza with cemí-shaped hills in background (a), and petroglyph 17 a teared or crying facial image (b). Scale 10 cm. (Courtesy P. Roe and see Oliver 2005: fig. 7.21).

(Troumassan Saladoid) of the Lesser Antilles. Thus Petitjean Roget (2015: 312, lower) shows a human face from a Troumassoid jar from Pearls, Grenada, with painted tear marks descending from the incised eye of that appliqué, modeled and painted visage. He also relates that teared image to a heart-shaped petroglyph with short “tear” markings from the Taíno culture at the Voûte à Minguet site, Haiti (Petitjean Roget 2015: 312, upper) and its connecting image (in terms of chronology, if not place), a modeled Suazoid adorno from Paquemar, Martinique (AD 650–1000) with curved incised “tear” lines descending from its eyes (2015: 312, middle).

In terms of the tear marks found on other petroglyphs from the Lesser Antilles, Petitjean Roget (2015: 17, 73, 284) illustrates a wrapped ancestral figure from the mouth of the Carbet River, Capesterre, in Guadeloupe, first described by Père Breton. That carving has curved “weeping” channels from its eyes. The figure is nested inside what almost looks like a pointed three-pointer (the encisted figure has twin up-raised arms). Richard (2009: fig. 10.4) shows another “wrapped-body petroglyph [the elongated body and face pecked into the stone]/pictograph [with prominent pigment painted to depict] . . . crying eyes from Grotte du Morne Rita, Marie Galante Island,” in a unique combination artwork from that small island near Guadeloupe.

On the other side of the Caribbean, in Jamaica, we also find anthropomorphic faces with “tear” lines descending from their eyes (Atkinson 2009: figs. 4.5a, b, c from Cuckold Point/Hull Cave in the parish of Manchester), which she suggests “may be representations of the Taíno rain deity Boínayel.” Fernández Ortega et al. (2012: 24) conclude that one petroglyph from the Cueva de Los Bichos in the Maisí region of the Guantánamo province in eastern Cuba represents the rain god, again due the presence of tears running from the eyes down the cheeks. Calvera and Funes (1991: fig. 8) consider the crying eye design element to apply to pictographs with lines below the chin from Cueva El Indio in the Sierra de Cubitas area of Cuba, as well as the actual tear lines from eyes on ceramic handles from nearby horticultural sites. Since this motif, both in pictographs and petroglyphs (and other media), therefore spans nearly the whole Caribbean, it may be suggested that it represents a widespread concern for the control, or evocation, of rain for horticultural fertility in a changeable environment, and one particularly of interest for Late Ceramic Taíno groups in the northern Antilles.

Summary and conclusions

What little enigmatic rock art we have from Archaic populations of the Antilles (principally the Casimiroid-affiliated cultures of the western Greater Antilles, specifically the Guanahatabey [Rouse 1992] of central and western Cuba and the Naborey of Hispaniola), in their geometric or stylized figurative pictographs, hints at a concern for itinerant tending of oil-rich palm-fruits, an evolutionary precursor to horticulture. That inference, however, rests on tenuous, if tantalizing, ethnographic analogy with living Amazonian foragers. Moreover, it is based on equally contestable similarities of some of the crossed line pictographic motifs with palm fronds. The other common motifs in this Archaic rock art—spirals and concentric circles—can be interpreted in several ways. They could relate to the entoptic images of trance states, or symbolize the pools and springs which would have been important as the base camps for their collecting strategies. However, that identification is based on even more remote ethnographic analogy with Australian foragers. Although also consonant with a common interpretation of similar motifs, often associated with water, in later horticulturalist Caribbean petroglyphs, such an identification is only viable using visual analogy, and therefore may or may not reflect ancient reality. Nevertheless, if such a picture derivable from rock art hints at the possibility of bands moving from sources of water in search of animals and vegetative food in the form of fat-rich palm kernels, that would provide some developmental context for the Archaic experimentation with cultigens (Pagán Jiménez 2013), and their limited innovation of ceramics (López Belando with Hayward 2009: 111) attested by several sites in Hispaniola.

Our search for the role of rock art in horticultural societies then experiences an apparent abrupt hiatus with the arrival of the migrating

horticulturalists and ceramic-making Saladoid groups into the Lesser Antilles and northeast Greater Antilles beginning around 800 BC. Inhabitants of a riverine Amazonian-Orinocan world of little stone, such people would have had little opportunity to engage in rock art before their departure from the mainland. We suggested that the lack of rock art production on stationary surfaces was related to a settling-in or regionalization process (as others have for cultural components from settlement systems to pottery). This process was at first marked by maintaining strong ties to continental homelands. During the succeeding Late Ceramic, cultural relationships transition to regional social and exchange networks, as well as to an appreciation for the new rock resources for visual expression and material culture production. We also argued that the production of three-pointers during the Saladoid provided evidence for a preoccupation with factors affecting soil fertility, as a means to ritually increase crop production, in addition to an interpretive context for their presence as petroglyphs and pictographs on stationary rock surfaces in the Ostionoid. Both the continued production of simple utilitarian three-pointers and the new rock art motifs of particularly three-pointer and anthropomorphic teared images, attest to an increasing concern for good harvests and abundant rains that were necessary to support an increasing population and sociopolitical stratification in the Greater Antilles.

All of this seems to echo Rappaport's (1971) concept of ritual regulation where the animistic religion of egalitarian spirits and its associated arts shift to a polytheistic one of suitable "departmental gods"—former spirits who now are identified as having specific roles (weather control, health) within an interrelated hierarchy (Swanson 1960). In a Caribbean context, weather control passes from spirits→god/cemís, potentially identified as Yucahú and Boinayel. These "emergent" deities and their polytheistic companions now serve, along with their rituals and ceremonies at ball parks/dance plazas, to ritually regulate the increasingly essential and intensified crop-based portion of the subsistence base. Such resources were necessary to generate a dependable food surplus which, in turn, supported numerous commoners and above them an increasingly diversified and interconnected (via marriage alliances) set of noble (nitaíno) and royal (cacical) ranks (Wilson 1997). Like Geertz's (1980) theatre states, the principal task of these complex chiefdoms was to make "inequality enchant," and the way that was accomplished was in part via an élite corporate (à la Moseley 2001) visual or art style constituting a "Taíno Cultural Nation" (Roe with Roe 2015) that encompassed many different, but acculturating ethnicities. Prominent in that visual style was the medium of rock art, specifically petroglyphs and pictographs, which projected their power and influence via identification with, or appropriation of, the departmental gods'/cemís' natures. On a more fundamental common cultural level, the rock art chronicles the watery travels of the dead along a "water gyre." Their journey begins in central cordilleran caves and underground rivers, and continues flowing to river boulder sites and seasonally flooded

plazas. From thence the journey of the dead proceeded to the beach rock petroglyphs near the ocean, and from there to the Land of the Dead (Coaybay) in the west, only to see, via rain, the cycle begin anew.

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Part IV

Caribbean versus Pacific farmers



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8 A comparative study of pre-colonial farming in the Caribbean vis-à-vis the Pacific

*Basil A. Reid, Frank R. Thomas, and
Scott M. Fitzpatrick*

Introduction

This chapter places the spotlight on pre-colonial farming in the Caribbean vis-à-vis the Pacific. Our discussion primarily revolves around the following: (1) major types of cultivars and domesticated animals coupled with their geographic ranges and chronologies; (2) types of farming techniques (swidden agriculture or *conucos*, mounded fields or *montones*, terraces and raised fields); and (3) socio-political organizations that underpinned pre-colonial farming in the two regions (tribal-based polities and chiefdoms).

In geographic terms, the Caribbean and the Pacific are markedly different in size. The Caribbean contributes only 0.15 percent (Fitzpatrick and Keegan 2007) of the earth's surface and has a combined land area of 240,000 km² (93,000 square miles). The Caribbean Sea, which is similar in size to the Mediterranean, encompasses an area of 2.75 million km² (1.1 million square miles) and stretches from Cuba and Hispaniola to Panama and from the Antillean chain of islands in the east to the Yucatán. In sharp contrast, the Pacific is the world's largest ocean at 165.25 million km² (63.8 million square miles) in area, covering around one-third of the earth's surface. The Pacific Basin extends from the southern boundary of the Arctic Ocean in the north to the Southern Ocean in the south (Figure 8.1). It is bounded by Asia and Australia in the west and the Americas to the east in what is commonly known as the "Ring of Fire" due to its high levels of tectonic activity and volcanism. The Pacific Island region consists of more than 25,000 islands and covers more than 800,000 km² (300,000 square miles) of land—of which New Zealand and the island of New Guinea make up approximately nine-tenths. While the Caribbean is narrowly classified as tropical in terms of its climatic conditions, oceanography, biogeography, terrestrial, and aquatic ecosystems (Gobin 2012; Sealey 2010), the sheer geographic size of the Pacific causes it to straddle a variety of tropical, sub-tropical, temperate, and arctic zones, with each zone being characterized by its own set of environmental particularities (Holland and Kay 2013; Manner et al. 2013; Nelson 2013; Sturman and McGowan 2013). Despite these differences, there are some important similarities between the Caribbean and the Pacific

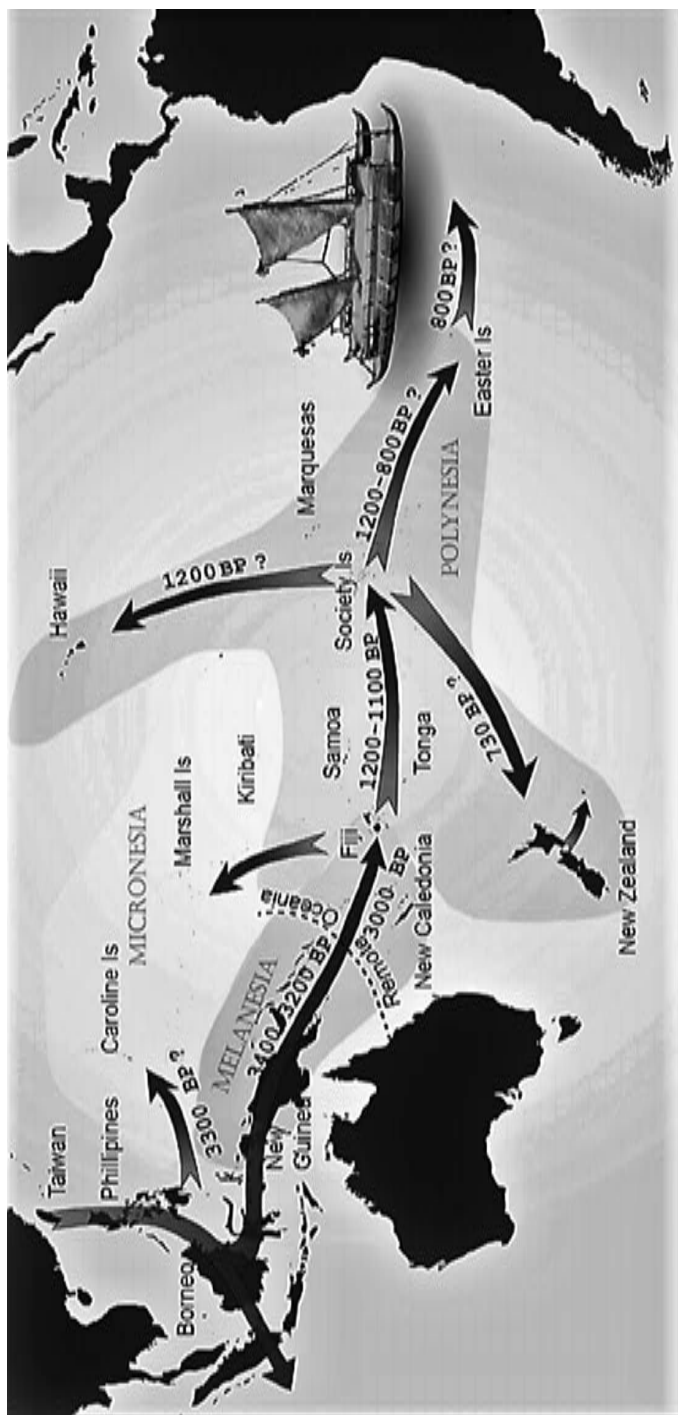


Figure 8.1 Map of the Pacific Ocean showing the major cultural divisions and the boundary between Near and Remote Oceania (downloaded from Google and adapted with assistance from D. Bhartu).

that provide ample grounds for a comparative study of pre-colonial farming and beyond (Boomert 2011).

Similarities between the Caribbean and the Pacific

Most of the thousands of islands in the Caribbean and the Pacific that were occupied prior to European contact are quite small, with populations that developed as the products of both maritime and terrestrial adaptations to island spaces within large expanses of water. The intense level of population dispersal, colonization, exchange behaviors (with the aid of watercraft technology, navigational or wayfinding skills, etc.)—and in some cases island inter-visibility within parts of both the pre-colonial Caribbean and the Pacific—make the two suitable to explore regional rather than island-specific studies (Boomert 2011; Curet and Hauser 2011; Fitzpatrick and Ross 2010; Irwin 1994; Leppard 2014; Reid 2009; Rouse 1992; Thomas 2013; Torres and Rodríguez Ramos 2008; Wilson 2007). In island archaeology, there is an emphasis on islands as distinct physical and social entities, which can in some ways serve as ideal units of analysis that show intrinsic characteristics essentially dissimilar from those on mainland areas (Boomert and Bright 2007; Curet 2004; Fitzpatrick 2004). Alternatively, Rainbird (2007) discusses the historical construction of this characterization and questions the basis for such an understanding of island archaeology. Through a series of case studies of prehistoric archaeology in the Mediterranean, Pacific, Baltic, and Atlantic seas and oceans, he argues for a decentering of the land in favor of an emphasis on the archaeology of the sea and, ultimately, a new perspective on the making of maritime communities (also see Boomert and Bright 2007). However, there are inherent issues with this approach (e.g., see Fitzpatrick 2007). Given the critical role of the circum-Caribbean in Antillean pre-colonial migration, colonization, and trade (Reid et al., 2014), this region will of necessity be included in the following discourse on pre-colonial farming.

Another similarity between the Caribbean and the Pacific are the correlations between speech communities and material culture, which can be used to track pre-colonial migratory routes and patterns of colonization. In the Pacific, these correlations can safely be made with respect to Papuan (non-Austronesian) and Austronesian speakers, while in the Caribbean there are strong correlations between proto-Arawakan languages in the Antilles (e.g., Lokono, Island-Carib, and Taíno) and pottery styles (Granberry 2013; Pawley 2013; Rouse 1992).

The emerging research agenda of historical ecology provides another useful approach for comparatively studying the Caribbean vis-à-vis the Pacific. Historical ecology, also sometimes referred to as ‘human ecodynamics,’ can be defined as “the complex, historical interactions between human populations and the ecosystems they have inhabited” (Kirch and Hunt 1997: 2). Research has clearly shown that for the Caribbean (Fitzpatrick and Keegan

2007; Fitzpatrick et al. 2008), Pacific (Fitzpatrick and Donaldson 2007; Kirch and Hunt 1997), and other island regions (Rick 2008; Rick and Erlandson 2008), human arrival instigated a number of catastrophic events to local ecologies (Fitzpatrick 2014: 180). By studying the archaeology and historical ecology of island and coastal environments around the world, under the premise that islands can serve as useful ‘model systems’ (Kirch 2007; Vitousek 2002), we can better understand how humans developed socially and biologically through time, as well as the impacts people had on their environments.

Another point of comparison is the heavy dependence of root crops characteristic of both the pre-colonial Caribbean and Pacific. Although not a root crop, maize was also an important cultivar in the pre-colonial Caribbean (Lane et al. 2008; Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez et al. 2015). Like the Caribbean, where manioc (a root crop) (*Manihot esculenta*), zamia (Zamiaceae), and sweet potato (*Ipomoea batatas*) were extensively cultivated by pre-colonial peoples, different varieties of taro (Araceae), also a root crop, continue to be a major staple throughout the Pacific. In addition, the early economies of both geographic regions were characterized by horticulture and aboriculture, with farming being part of a larger network of other food acquisition methods such as collecting, fishing, and hunting (Boomert 2011; Fitzpatrick 2014; Kirch 1994; Reid 2009; Rouse 1992; Thomas 2013; Wilson 2007).

The Caribbean

Caribbean cultivars

Until recently, there was general agreement among Caribbean archaeologists that Saladoid groups were the first horticulturalists and also introduced pottery to the region, hence the temporal convention “Ceramic Age” commonly used to describe this event. Saladoid sites are found in abundance from Trinidad and Tobago to Puerto Rico, but who curiously ventured no farther west or north. Saladoid populations, who arrived in the Caribbean ca. 500 BC, brought visible signs of their South American farming background, such as ceramic pots and griddles for cooking cassava and probably other breads, as well as physical evidence of a settled village life, such as large middens and plazas. However, the notion that Saladoid introduced pottery and agriculture to the islands is largely based on outdated and/or simplified models of cultural development and population dispersals (Keegan 2006; Reid 2009; Rodríguez Ramos 2007).

Mounting archaeological data indicate that pottery-making and agriculture were already practiced in the islands by both the Archaic Casimiroid and Ortoiroid peoples before the Saladoid arrived (Keegan 2006; Reid 2009; Rodríguez Ramos 2007). The presence of certain plant remains on Archaic sites suggests that many of the foods that were allegedly introduced by the

Saladoid were already an established part of Archaic horticulture (Newsom 1993; Newsom and Wing 2004). Plants identified in Archaic deposits, including zamia or coonite (*Zamia pumila*), cupey (*Clusea rosea*), wild avocado (*Persea americana*), yellow sapote (*Pouteria campechiana*), primrose (*Oenothera* sp.), mastic bully (*Mastichodendron foetidissimum*), trianthema (*Trianthema portulacastrum*), and palms (Palmae), have all been found in the macrobotanical and microbotanical record of Puerto Rico (Pagán Jiménez et al. 2005; Reid 2014a). Fruit trees in the sapodilla family (Sapotaceae) (Figure 8.2) are represented by seeds and wood fragments from Twenty Hill on Antigua and seed remains from Hichmans Shell Heap on Nevis. Other seeds from Archaic Age sites derive from herbaceous or slightly woody plants. Seeds that are provisionally assigned to the genus *Siphonoglossa* sp. (Acanthaceae), cossie balsam, were recovered from Hichmans Shell Heap (Newsom and Wing 2004; Reid 2009, 2014). This plant is documented among the flora of the northern Lesser Antilles, though it does not seem to have been recorded as part of the modern vegetation of Nevis (Newsom and Wing 2004). Its archaeological presence suggests that this plant was used by Ortoiroid (Archaic) groups on the island. Cossie balsam is potentially another species that had medicinal value (Acevedo-Rodriquez et al. 1996; Reid 2009, 2014).

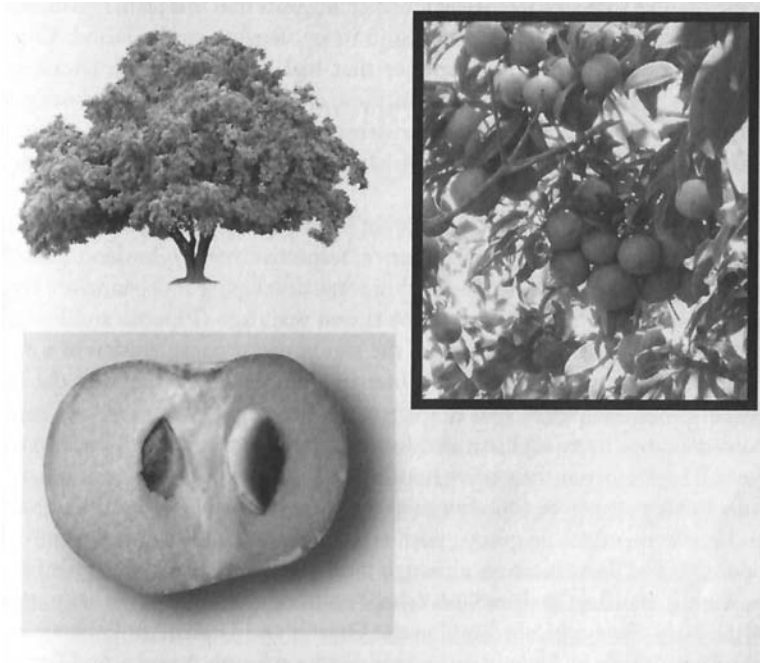


Figure 8.2 Sapodilla (*Sapotaceae*). Courtesy of the University of Alabama Press.

The growing application of archaeometric techniques, such as starch grain analysis, dental calculus, and stable isotopic analysis, have provided new insights into the range of cultivars that were characteristic of Caribbean pre-colonial societies. For example, new evidence, based on the analysis of starch grains recovered from grindstones, has provided the earliest maize (*Zea mays*) in the Caribbean and the earliest sweet potato (*Ipomoea batatas*), zamia (*Zamia* sp), achira (*Canna* spp.), and chili pepper (*Capsicum*) in the Americas, found at the site in southwestern Trinidad (Pagán Jiménez et al. 2015) (see Figure 8.3). The site, which dates back to 7790 years cal BP, was inhabited by Archaic peoples (Reid 2014b; Reid and Callaghan 2014; Rouse 1992; Wilson 2007). The antiquity of the maize discovery here is significant in the context of Caribbean pre-colonial foodways. Mounting evidence suggests that maize was in fact an important food staple in the region. In addition to the early maize discoveries at St. John in Trinidad (Pagán Jiménez et al. 2015), an abundance of maize pollen dating to AD 1060 was found in sediments from two lakes around one mile in elevation in the Dominican Republic, Laguna Castilla, and Laguna de Salvador (Lane et al. 2008). Further, a study of starch grains trapped in dental calculus from the pre-colonial insular Caribbean (dating to ca. 350 BC to AD 1600) indicate that maize was more commonly consumed in the insular Caribbean than originally thought (Mickleburgh and Pagán Jiménez 2012). The recent discovery of maize at St. John suggests that it was dispersed into the insular Caribbean from the Balsas watershed in Mexico around 9500 cal BP via Panama and Colombia, far earlier than what was commonly assumed (Pagán Jiménez et al. 2015).

Root crops appear to have been the focus of food production in the pre-colonial Caribbean; there are at least seven types thought to have been grown in the Caribbean just prior to the arrival of Europeans (Newsom 2014). In their study of starch grains trapped in human dental calculus through the Early and Late Ceramic Ages in the insular Caribbean (dating to ca. 350 BC to AD 1600), Mickleburgh and Pagán Jiménez (2012) identified a large number of tuberous plants, including marunguey (*Zamia* sp., *Zamia pumila*, cf. *Zamia erosa*), sweet potato, cocoyam (*Xanthosoma* sp., *Xanthosoma* cf. *sagittifolium*), arrowhead (cf. *Sagittaria* sp.), and manioc. The latter was represented by a single starch grain retrieved from a female individual at Malmok, Aruba (burial 10). The rhizomes Cannaceae (which includes the economic species such as achira or gruya), Marantaceae (for which arrowroot is one of the better known economic species), and Calathea (*Calathea* sp.) were also tentatively identified, as were a number of legumes, both domesticated, such as *Canavalia* sp., common bean (*Phaseolus vulgaris*), and wild bean (e.g., Fabaceae, Leguminosae).

Bercht et al. (1997) indicate that all Saladoid groups grew manioc; prepared land for cultivation using similar methods; had increased gathering, hunting, and fishing to maintain an economic and environmental balance; and lived in large huts, or bohíos, which infer the habitation of either large

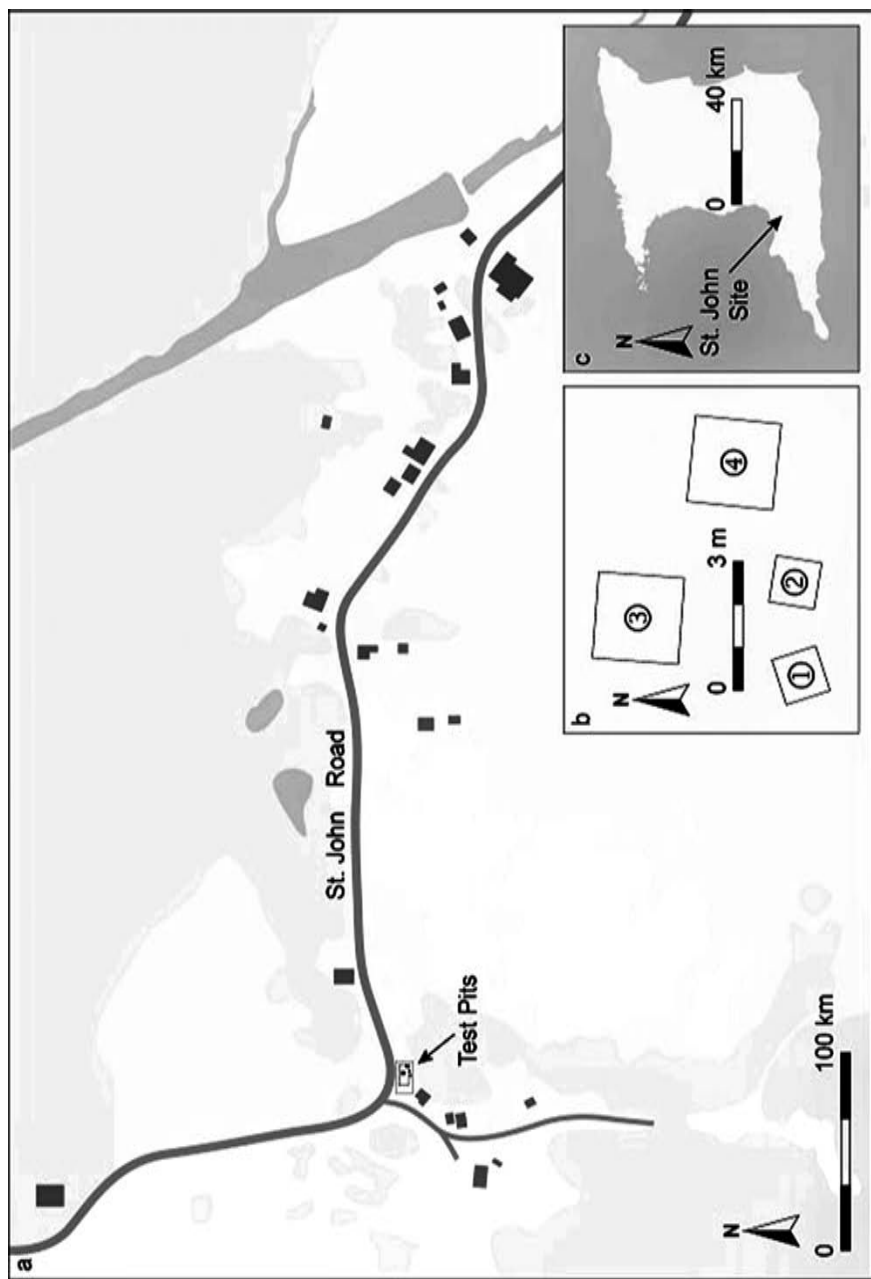


Figure 8.3 St. John site in southwestern Trinidad. (Produced by C. Hodge).

or extended families. Rouse (1992) posits that cassava (casabe) was the principal root crop of the Taíno, followed by the sweet potato (batata). Cassava thrived in a broad range of local conditions, from wet to dry. According to Taíno mythology, it was the culture hero Deminán and his brothers who stole manioc from the high god Yaya and brought it to the Taíno people (Keegan and Carlson 2008). The story mirrors other cultures' myths in which humans wrest their means of subsistence from supernatural beings. This myth was referenced and recreated when the Taíno buried stone carvings of Yocahu (literally, the giver of manioc) in agricultural fields. The stones were triangular in shape and resembled a sprouting tuber. The god image on the "three-pointed stones" often has an open mouth for which to eat the soils and facilitate the growth of tubers. Yocahu was the Lord of Yuca and also the male fertility god (Keegan and Carlson 2008). En Bas Saline site in Haiti (dating from AD 1200–1500) is one of the few sites to produce macro remains of these crops, including manioc and possibly also sweet potato. While identifying starch grains reflecting a variety of plant foods (mostly tuberous root crops), including marunguey and sweet potato, recent research by Mickleburgh and Pagán Jiménez (2012) did not find any indications for the traditionally assumed heavy reliance on manioc cultivation in the region for the period 350 BC to AD 1600. This suggests that the interpretation of manioc having been of paramount importance across successive pre-colonial native groups in the Caribbean may be more a function of ethnohistoric and ethnographic records than archaeological reality.

Seeds of chili pepper (*Capsicum* sp.), another of the ethnohistorically mentioned crops, were also recovered from En Bas Saline (Newsom 2014; Florida Museum of Natural History www.flmnh.ufl.edu/histarch/ebs_intro.htm, accessed November 2, 2015). A series of important arboreal taxa that have also been identified from Ceramic Age assemblages, including papaya (*Carica papaya*), guanábana (*Annona* sp.), achiote (*Bixa orellana*), and cojóbilla (*Anadenanthera* sp.), were introduced from outside the region. Nevertheless, their continued use in the Caribbean islands over the centuries demonstrates continuity with mainly South American traditions involving agricultural investments, home gardening, and a variety of ethnobotanical practices and ritual and belief systems (Newsom 2014).

An important cultivar used for magico-ritual purposes was cohoba. *Cohoba* (or *cohóbana*) refers to a psychotropic drug that is snuffed or inhaled through the nostrils and is also the vernacular name for the tree from which the seeds for the snuff are derived (Torres 2014). Two species of the genus *Anadenanthera* (*A. peregrina* and *A. colubrina*) have historically been used by indigenous peoples of the Caribbean and South America as a powerful hallucinogen to accompany ritual ceremonies (Pagán Jiménez and Carlson 2014; Torres 2014). Archaeological evidence for the plant has been recovered in the form of starch grains from a coral milling base from the habitation site of CE-11 in eastern Puerto Rico (Pagán Jiménez 2011) and charred wood from archaeological contexts at the ceremonial center of

Tibes in the south-central part of the island (Newsom 2010), with associated paraphernalia in the form of snuffing tubes and inhaling bowls found on at least ten different islands (Fitzpatrick et al. 2009; Kaye 2010).

Animal domestication

There is evidence for some degree of animal management in the pre-colonial Caribbean. For example, Muscovy ducks and turtles may have been managed, and capromid rodents (Capromyidae; also known as hutias) were apparently intentionally moved to islands where they were not originally found (Newsom 2014). Other small animals were intentionally introduced from South America (e.g., agouti, *Dasyprocta leporine*; guinea pig, *Cavia porcellus*; opossum, *Didelphis marsupialis*; and armadillo, *Dasybus novemcinctus*) for reasons that are still unknown. The potential significance and roles of these captive fauna in Caribbean indigenous social and economic systems could certainly have served at least to enhance protein sources in this region, where terrestrial vertebrate fauna were impoverished (Newsom 2014), though their generally low frequencies in archaeological deposits suggests that this was not the primary goal.

There is some indication that guinea pigs were exclusively used by elite groups in late pre-colonial societies in the Caribbean (Curet and Pestle 2010; Newsom 2014); however, this has been disputed in a recent study by LeFebvre and deFrance (2014). In their examination of 218 bone fragments from 18 sites on 9 different islands (Jamaica, Hispaniola, Puerto Rico, Vieques, St. John (US Virgin Islands), Antigua, Carriacou, St. Lucia, and Curaçao), LeFebvre and deFrance (2014) argue that guinea pigs were introduced to the islands only after AD 500, possibly to the Greater Antilles first. Almost all were recovered from midden contexts, which suggest that these animals were consumed as food and not considered an exotic or high-status food source with restricted consumption or as other non-food (e.g., for rituals). The spatial and temporal patterns of guinea pigs suggest that they may have been linked to social identity and new patterns of trade, interaction, or population movements between the Caribbean and South America during the second half of the Caribbean Ceramic Age.

Human interaction with domesticated animals besides guinea pigs is clear from the presence of dogs; evidence includes dog burials and tooth modification (perhaps for a muzzle or other restraining device). Throughout pre-colonial sites in the Caribbean, domesticated dog (*Canis familiaris*) remains are found more often in human burials and are relatively rare in middens. This suggests an intimate association of domesticated dogs with native groups and a cultural significance of dogs over and above a food source (Newsom and Wing 2004). Domesticated dogs may have provided companionship and were probably used during hunting expeditions. Dog burials have been found at Silver Sands in Barbados (Drewett 1999; Newsom and Wing 2004) and the sites of Anse à la Gourde and

Morel on Grande-Terre, Guadeloupe. Apparently, the practice of burying dogs with humans is only found in Early Ceramic Age assemblages (Hoogland and Hofman 2013). Several additional types of animals (e.g., capuchin monkey [*Cebus* sp.] and macaw [*Ara autocthonos*]), may also have been kept as companions or pets (Newsom 2014).

Primary farming techniques

As earlier indicated, the primary techniques characteristic of the pre-colonial Caribbean were swidden agriculture or *conucos*, mounded fields or *montones*, and raised fields. While *conucos* are sometimes described as mounded fields (Rouse 1992; Witteveen and Reid 2014), such a description is more appropriate for *montones*. What appear to be terraces have been found at Las Planás in Puerto Rico (Ortiz Aguilú et al. 1991) and elsewhere in Puerto Rico. Usually associated some distance away from the villages, *conucos* were areas of the forest that were cut and burned and then planted in a haphazard manner with a variety of cultigens grown together. Characterized as ‘slash-and-burn’ horticulture, a plot of land was cleared of trees and bushes and then allowed to dry. Large trees were ‘girdled’ to cause them to drop their leaves (Keegan and Carlson 2008: 71). Just prior to the start of the next rainy season, the cut vegetation was burned to release nutrients that were bound up in the vegetation. A wide variety of crops were then planted in the cleared-and-burned land and sown with a digging stick (*coa*). A *coa* was about two meters (six feet) long with a fire-hardened tip (Keegan and Carlson 2008: 71). The term *conuco* refers not only to farmed fields but also to the strategy of planting different staples in the same field (i.e., it is not monoculture) (Curet personal communication 2016). *Montones*, on the other hand, are mounded fields resulting from the technique of collecting and making heaps of top soil to plant mostly root crops (Curet personal communication 2016).

There is growing evidence for the practice of slash-and-burn agriculture by Archaic groups in the Caribbean. Paleoecological studies carried out on the northern coast of Puerto Rico indicated a significant increase in fires (i.e., charcoal particulate), which began between 5500 and 3800 cal BP near Laguna Tortuguero, possibly as the result of anthropogenic activities (Burney et al. 1994; Pagán Jiménez 2013: 395). Human groups in and around the Angostura site in northern Puerto Rico were possibly exploiting resources in the area from around 6900 cal BP, eventually settling Angostura between 4400 and 3800 cal BP. These and/or other related groups are likely responsible for the changes observed in the paleo-fire sequences due to the possible development of slash-and-burn agricultural systems (Pagán Jiménez 2013: 395–396). Likewise, on Vieques island (Sara et al. 2003), charcoal particulates increased drastically by around 2840 cal BP, suggesting that Archaic peoples were substantially modifying their floristic environment, perhaps for plant production purposes (Pagán Jiménez 2013: 395). The recovery of

macrobotanical remains belonging to some exotic arboreal taxa and some grasses, such as *Portulaca* sp. in other previously studied Archaic sites of the Antilles (Newsom and Wing 2004), suggests the development of arboriculture and home gardens, and/or the creation of agricultural plots (i.e., slash-and-burn) whose disturbances stimulated the appearance of colonizing plants (Pagán Jiménez 2013).

It would appear that continued population growth forced local communities in the pre-colonial Caribbean to abandon the attenuated slash-and-burn system and develop more intensive agricultural techniques, which included the development and use of more sophisticated irrigation systems, and a more intensive use of floodplains along rivers (Curet 2005: 146). The Taíno were farmers who cultivated both house gardens (with as many as 80 herbs), medicinal plants (including *tobacco*), and intensively cultivated large fields (*conucos*) that included semi-permanent mounds (*montones*) on which different varieties of manioc and sweet potato were cultivated (Keegan 2013: 72). The concentration of organic material from the stratum in *montones* created a matrix of loose dirt that allowed root crops to grow faster and bigger than would have occurred had only traditional slash-and-burn techniques been used. In addition, the higher elevation of the *montones* improved the drainage of the soil, avoiding contact between water and the roots for long periods of time. Areas, particularly those along river flood plains where nutrients were annually renewed by flooding, supported a more intensive form of cultivation. In these areas, the thin soil layer was piled into semi-permanent mounds (*montone*) which provided loose soil to plant and harvest root crops (Keegan and Carlson 2008: 72–73). A *montone* was about one meter (three feet) high and three meters (nine feet) in diameter with flat tops (Keegan and Carlson 2008: 73). Although manioc can grow in all classes of soils, drier conditions have been reported as preferred for its growth (Curet 2005: 146; Roosevelt 1980: 121–122). Manioc is extremely drought resistant, has a high caloric content and can, though it matures in ten months, be stored in the *montone* fields for up to three years before harvesting. Bartolomé de Las Casas reported that 20 people working 6 hours a day for 1 month to plant manioc in the Taíno fashion could feed 300 people for 2 years (Keegan and Carlson 2008: 73).

The presence of terraces (with stone retaining walls) at Las Planás in Cayey, Puerto Rico (Ortiz Aguilú et al. 1991) provides possible evidence that some native groups had developed more sophisticated irrigation methods uncommon to the region. The construction, design, location, and layout of the Las Planás terraces suggest that their purpose was mainly agricultural; the retaining walls were specifically designed and constructed to hold the soil in place while allowing the water to filter through; the terrace benches are level and parallel to each other and contain loose, dark soil of a very high organic content, lying on top of a compact stone base at the bottom (Ortiz Aguilú et al. 1991). It appears that the hillside was selectively utilized by exploiting mostly its southern face, thus obtaining maximum sun exposure (Ortiz Aguilú et al.

1991). There is evidence that links these structures to a pre-Taíno multi-component village site that exhibits late Puerto Rican Saladoid, classic and late Puerto Rican Ostionoid, as well as Puerto Rican Chicoid (Capá) ceramics (ca. AD 700–1100). At least two plazas and several petroglyphs have also been discovered associated with the village site (Ortiz Aguilú et al. 1991). At Utuado-Caguana, also in Puerto Rico, José Oliver found what appear to be artificial agricultural terraces (Drewett and Oliver 1997), similar to those found at Las Planás (L. Antonio Curet personal communication 2016; Reniel Rodríguez Ramos personal communication 2016). Similar terraces have also been found at Ponce and Jayuya in Puerto Rico (L. Antonio Curet 2016 personal communication; Reniel Rodríguez Ramos personal communication 2016). It is important to note that islands like Cuba and Hispaniola also have evidence for agricultural works such as terraces and *montones* (Ulloa Hung 2013). Clearly, these purported features deserve further investigation to examine their construction techniques, purpose, and role in pre-colonial subsistence and/or other socioeconomic activities.

Ancient raised fields, found in coastal swamps in the Guianas (comprised of French Guiana, Suriname, and Guyana) constitute yet another farming technique (Rostain 1994, 2014). Although no raised fields have so far been identified in the insular Caribbean, those found in the Guianas are unique to the region and therefore significant to our understanding of native farming ingenuity and innovativeness in the region. Most of these earthworks date back to the first millennium AD, but some were made as early as 1000 BC and used up until European conquest and even beyond. In fact, the main reason for building raised fields is to control excess water for agricultural purposes. The earliest raised fields found are in Suriname ca. AD 350 by the Barrancoid inhabitants of western Guyana. However, most of the earthworks are associated with Arauquinoid sites in Guyana, Suriname, and French Guiana (Rostain 2014).

In the flooded savannas, raised fields seem to have been the ideal agricultural answer to population growth, because this technique made intensive agricultural land use possible. Population density may have reached 50 to 100 persons per square kilometer in areas with raised fields. Arguably, from AD 650, the intensification of agriculture (based on raised fields) resulted in population growth, social complexity, intersocietal interactions, craft specialization, and long-distance trade. These factors led to the emergence of chiefdoms along the coast of the Guianas (Rostain 2014).

Pre-colonial farming in the Pacific

Food production in the western half of the Pacific Island region emerged at the end of Pleistocene, after more than 30,000 years of human settlement. Agricultural expansion and intensification would eventually alter terrestrial environments on nearly every habitable island scattered across the world's biggest ocean (Kirch and Hunt 1997). The impacts can sometimes be traced

to the early stages of human settlement, leading in some cases to resource depression, extirpation, and extinction. By contrast, the influence of indigenous societies on marine resources is less well documented (Anderson 2008; Morrison and Hunt 2007) and remains a fruitful topic for research in light of suggestions that rapid dispersal, notably in the case of the Lapita expansion across the southwest Pacific beginning about 3,400 years ago, could have been driven in part by the impact of early humans on nearshore and intertidal resources of high value that could be efficiently harvested, such as flightless birds, colony-breeding seabirds, turtles, a variety of reef fish, and invertebrates (Kennett et al. 2006; Szabó and Amesbury 2011).

Cultivars

All Pacific Islands communities practiced, and most continue to practice, horticulture as the basis of their subsistence economy. In association with natural land features, evidence of farming accounts for much of the patterning evident in the region's organically evolved continuing cultural landscapes. Although the principle cultivars of Pacific horticulture were brought to the islands from elsewhere, once introduced, food production was adapted and developed by communities in response to the unique constraints of the Oceanic environment. As people traveled eastward from Island Southeast Asia colonizing first Melanesia, Micronesia, and then Polynesia, they encountered for the first time high volcanic islands, atolls, and uplifted coral islands, each requiring different adaptations of the basic farming components.

When the makers of Lapita ceramics, assumed to be associated with Austronesian speakers from Southeast Asia, first crossed the navigational and seafaring divide between the southern end of the Solomon Islands and northern Vanuatu, to settle the islands of eastern Melanesia, Fiji, and western Polynesia, they took with them a range of cultivars and tree species and the knowledge of how to propagate, cultivate, and process them (Kirch 2010a). These cultivars included edible plants, tubers, nut and fruit trees that were also used in building, basketry, clothing, and for their pharmacological/psychoactive properties. For example, the widely distributed narcotic/hypnotic kava plant (*Piper methysticum*) was incorporated in ritual drinking ceremonies across many Pacific communities in Melanesia, Polynesia, and Micronesia (Lebot 1991). Betel nut (*Areca catechu*), with distribution in New Guinea, Solomon Islands, and western Micronesia, was chewed and produced a calming, euphoric, and occasional dizzying effect (Fitzpatrick et al. 2003).

While Lapita migrants had a mix of terrestrial foraging, maritime subsistence, and horticultural production, but without rice or other cereals (Bellwood 2013: 196; Horrocks and Nunn 2007; Pawley 2017; Valentin et al. 2010), and appeared to have introduced the first undomesticated (rats) and domesticated animals to the region (pig, chicken, and dog), several of their cultivars can be traced to New Guinea where wild or domesticated varieties have been identified as stone-tool residues and phytoliths from Late

Pleistocene and Early Holocene contexts, centuries prior to the arrival of Lapita (Denham 2006). Several of these cultivars may have been carried back into Southeast Asia before the Austronesian expansion across Melanesia (Bourke 2009). The list includes major Pacific staples, including *Colocasia* taro, ‘elephant-ear’ taro (*Alocasia macrorrhiza*), *Musa* bananas, the greater yam (*Dioscorea alata*), breadfruit (*Artocarpus Altilis*), and sugarcane (*Saccharum officinarum*). Indeed, New Guinea appears as one of the major independent world centers of early plant domestication, as supported by evidence for taro cultivation at the Kuk site about 10,000 years ago (Golson 1997).

Most of the cultivars grown in the region prior to European contact continue to be managed in many parts of the Pacific today. These also include the South American sweet potato (*Ipomoea batatas*), which was introduced to the Pacific Islands perhaps as early as 1,000 years ago, possibly through direct contact between communities in East Polynesia and South America (Yen 1971). Sweet potato, which has been found in archaeological deposits in Hawai’i as early as 600 years ago, was the staple crop of New Zealand at European contact, and reached the New Guinea Highlands only in the last few hundred years to become intensively cultivated throughout the region by the early 20th century.

While a host of cultivars have been readily adopted into the gardens and traditional horticultural practices of Pacific Islanders since European contact, the taro-yam complex continues to be the mainstay of most Pacific food production systems. The taro *Colocasia esculenta* is the most widespread of the aroids cultivated in Pacific Island gardens, but others including *Alocasia macrorrhiza* and the giant swamp taro, *Cyrtosperma chamissonis*, are also common (Figures 8.4 and 8.5). All are hydrophilic and have a natural habitat of damp areas near streams or in open swamps. Where such habitats are not found, taro cultivation required the development of water control systems.

In contrast to taro, yam vines (*Dioscorea* spp.) are tropophytic, or adapted to conditions in which periods of heavy rainfall alternate with periods of drought, having a growing period in the wet season, but are dormant in the dry. As they do not thrive in damp environments, cultivation requires drainage systems of mounds and/or ditches (Kirch 2000: 152). The different habitat and characteristics of taro and yam have provided a dichotomy of ‘wet’ versus ‘dry’ and irrigation versus dry swidden gardening (Barrau 1965; Kirch 1979).

At higher latitudes, a number of tropical crops could not thrive. In New Zealand, horticulture was dominated by the sweet potato, supplemented by yam, taro, gourd, and ti tree (*Cordyline terminalis*). Because of warmer conditions, food production had achieved greater success on the North Island compared to the South Island. However, the long coastline and vast land area of both islands provided ample opportunities for a hunting-gathering-fishing economy that included the exploitation of fern root, large sea



Figure 8.4 Terraced taro fields, Vanua Levu, Fiji. (Photo by F. R. Thomas).



Figure 8.5 Giant swamp taro grown in pits, Abaiang Atoll, Kiribati. (Photo by F. R. Thomas).

mammals, and giant flightless birds, ensuring an adequate diet without domesticated animals or a full complement of crops (Davidson 1983; Davidson and Leach 2001). Other islands lying outside the tropics such as the Kermadecs, Chathams, Norfolk, Rapa, and Easter Island posed similar challenges to the successful introduction of domesticated crops and animals (Prebble 2008).

Perennial arboriculture—agroforestry (the practice of cultivating wild and/or domesticated arboreal species)—is a distinguishing characteristic of some of the earliest settlements in the Pacific in the Late Pleistocene and Early Holocene, continuing with Lapita-era sites (Latinis 2000; Matthews and Gosden 1997). Examples include breadfruit (*Artocarpus altilis*), sago palm (*Metroxylon* spp.), Tahitian chestnut (*Inocarpus* sp.), candlenut (*Aleurites moluccana*), *Canarium* spp., coconut (*Cocos nucifera*), and screw pine (*Pandanus tectorius*). The latter two were valued as building material for baskets and thatch, as well as for their nutrients (Thaman 1990). Interestingly, the coconut, which is so ubiquitous today in the Caribbean, was a post-European introduction, while strands occurring along the west coast of Central America are believed to have been introduced by Polynesian seafarers (Ward and Brookfield 1992). Several of these species could be stored. Food preservation technology reached its zenith on atolls, as people developed ways to process certain foods that could last through periods of scarcity and for use as sea rations among communities that regularly travelled between islands, including fermented breadfruit and dried pandanus paste.

Agroforestry is described as a sustainable system of food production by virtue of the relative permanence of land use providing a wide range of subsistence needs, with crops requiring little direct cultivation beyond occasional mulching and replanting. Micronesia's 'breadfruit revolution' (Petersen 2006) between AD 1000–1500 has been explained in terms of the successful hybridization of seeded and seedless varieties originating from opposite directions (western and eastern Micronesia), which enabled population increase and the spread of the Eastern Carolinian matrilineal form of social organization, along with political and religious cult practices.

Animal domestication

Insular faunas tend to be disharmonious compared with those of nearby continents. Mammals are characterized by a few marsupials, limited to the Bismarcks and Solomon Islands, rats, and fruit bats. Only the latter dispersed to Remote Oceania prior to the arrival of humans (Kirch 2000: 54). Fruit bats, birds, coconut robber crabs (*Birgus latro*), and reptiles, some of which became extinct as result of direct predation or habitat alteration (Anderson 1989, 2010; Dye and Steadman 1990, 1997; White et al. 2010; Worthy and Anderson 2009), were the only edible terrestrial species east of the Solomons. However, even after the successful introduction of domesticated animals of Southeast Asian origin, including pigs, dogs, and fowl by Lapita peoples, marine resources (fish and shellfish), particularly from reef environments, continued to provide the bulk of proteins.

By virtue of the presence of marsupials, as well as bats, rodents, forest birds, and reptiles in Near Oceania, Pleistocene colonists of the region were able to extract inland resources by hunting, possibly accompanied by the

transfer of wild animals from the larger to the smaller islands. Examples include the bandicoot (*Echymipera kalubu*), cuscus (*Phalanger orintalis*), and wallaby (*Thylogale brunii*) (Flannery and White 1991; Leavesley 2006).

As noted earlier, agricultural expansion and intensification in Remote Oceania led to significant changes to island landscapes and associated fauna, reiterating the essential character of Oceanic islands as tending toward instability when isolation is broken down (Fosberg 1963). Rat populations, either accidentally or deliberately introduced by people, would have been especially threatening to nests and eggs of endemic ground-dwelling birds. With the decline of wild terrestrial fauna (and some shellfish resources), it can be assumed that introduced domesticates gained in importance at the same time that human settlements shifted to upland locations (Summerhayes 2010). However, only in the central highlands of New Guinea were pigs domesticated on a relatively large scale. This was made possible by the introduction of the sweet potato, via indirect European contact, about 300 years ago (Watson 1977). The 'Ipomoean Revolution' provided excellent fodder for pigs, which were not only bred for meat, but also fulfilled important social and symbolic functions in competitive feasting, initiation rites, dowry, weddings, and funerals.

Not all domesticates are equally represented in the archaeological record. In some instances, they did not survive long ocean crossings. In other cases, they would have competed with humans for scarce resources (Giovas 2006; Kirch and Yen 1982: 21).

Farming techniques

Shifting or swidden cultivation is the most widespread type of cropping system throughout the Pacific Islands. In areas where dry swidden is practiced, the landscape reflects a patchwork of active swidden gardens, recently abandoned gardens in stages of regrowth, and primary forest. Swidden gardens are considered the original form of horticulture in the region. Although dry swidden farming and small scale taro pond construction continue to be the most common traditional horticultural practice in the Pacific today, the continuation of these practices belies changes in horticultural practices in the past, visible in large scale landscape modifications in the relict cultural landscapes of a number of Pacific Islands.

Over time, some horticultural practices became more complex and labor intensive with the development of water control systems or irrigation and intensive dry field cropping systems, most probably in response to population increase following settlement and associated environmental degradation and declining soil fertility. Archaeological evidence associated with intensification of food production includes terracing, canals, or other forms of water control (Kirch and Lepofsky 1993), and ultimately led to more defined territorial divisions and evidence of defensive fortifications among many of the islands.

A good example of agricultural intensification is provided by research in Hawai'i. Taro pondfields were numerous on windward sides of islands, which receive more rain. Irrigation technology and coordinated water use played crucial roles in fostering political complexity by producing large surpluses for the ruling classes to further legitimize their position of authority (Allen 1991). It appears, however, that the most complex and militarily most powerful chiefdoms arose in dry, leeward areas where intensive cultivation of sweet potato, sugar cane, gourd, and banana was practiced (Kirch 1994: 318–319). Intensification of production in drier environments with the establishment of permanent field systems suggests that farmers possessed a good understanding of soil properties. For example, 'rock farming' or 'lithic mulching' like that practiced on Rapa Nui (Hunt and Lipo 2011; Kirch 2010b; Stevenson et al. 1999) is a technique whose potential has generally been under-appreciated by Western agronomists, but was well suited to high risk arid conditions.

Socio-political organizations underpinning farming communities

The Caribbean

Data from a variety of sources, particularly those archaeological and ethno-historic in nature, indicate that many islands in the Caribbean—particularly in the northern Caribbean—had substantial populations at European contact that relied on a multitude of resources that were both produced and acquired. How these groups evolved from more egalitarian-type social structures into ones more politically and economically complex is still unclear. In the case of eastern Puerto Rico, Curet (1996) has argued that in the earliest stages of the Ceramic Age, pristine chiefdoms showed very little evidence archaeologically for social differentiation, but that this slowly changed, with increasing emphasis on chiefs and elite members of society, which can be detected archaeologically in the 'devolution' of pottery that becomes less stylized and more coarsely made through time. Essentially, there appears to be a movement away from more personally stylized objects (e.g., ceramic vessels, lapidary items) to new ones that were larger and more ritual in nature (e.g., wooden idols, duhos).

While the question of how social complexity developed in the Caribbean is still under investigation, it is clear that Taíno groups—with their own unique cultural traits in the Greater Antilles and whose influence spread quickly into the Bahamas and some of the northern Lesser Antilles (notwithstanding issues of how 'Taíno' has traditionally been defined [Curet 2014])—were at the apex of sociopolitical development in the region. This was manifested in the much larger villages and higher population densities seen archaeologically and at European contact compared to what was present in the southern Lesser Antilles. As a result, it is perhaps no surprise that the

emphasis on ceremonialism and chiefly elites coincided with increased agricultural intensification needed to feed, manage, and control a growing population. While these changes can be seen archaeologically in terms of artifacts, monumental architecture like plazas/bateys, and more intensive island to island and island to mainland interaction spheres, it is particularly noteworthy that many of the standard elements that typically accompany these transitions (e.g., defensive fortifications, widespread irrigation networks, megalithic construction) are absent. Why these do not occur, and why there are distinct cultural differences between the northern and southern Antilles in later prehistory, despite the presence of active exchange networks and Taíno ideologies spreading southward, are important lines of inquiry for the future.

The Pacific

Polynesian agricultural intensification, especially in East Polynesia, has been associated with the increasing social complexity in classic anthropological models explaining the rise of hierarchical societies and chiefdoms such that agricultural intensification and the production of surplus has been considered a prerequisite to supporting chiefly societies (Kirch 1984). However, the relict landscapes of some islands in Melanesia, where societies at least in the ethnographic period were not considered by anthropologists to be hierarchical, also bear testimony to the past investment of much time by organized labor in large scale horticultural production (Sand 1996).

Even in some parts of Polynesia where social hierarchies were not highly developed, such as in New Zealand, horticultural traditions witnessed the acclimatization of five tropical species to temperate climatic conditions, expansion of the genetic diversity of the original planting material by selection of large areas of garden soil to improve yields, and the selection of the fastest maturing sweet potato varieties known. Intensive cultivation of the sweet potato is exemplified by storage pits. As elsewhere in Polynesia, this pattern of intensive land use is associated with a rapidly growing population and resource stress caused by environmental degradation (Leach 1999). In association with the evidence of intensive horticulture, large defensive systems in the shape of ditches and other earthworks or the construction of palisades and terraced fortifications, pattern the landscape throughout many islands and attest to the competition for resources (Nunn et al. 2007).

Summary and conclusions

As can be seen from the comparison of the Pacific and Caribbean, both have a strong emphasis on root crops that were calorically high, grew well in tropical environments, and provided the necessary framework for populations to settle and thrive on islands. In combination with a suite of many other plants used for nutritional, pharmacological, and psychoactive

purposes—along with a rich array of marine foods—pre-colonial groups in these regions were able to successfully adapt to a wide range of island types (e.g., cays, atolls, topographically complex volcanic islands) with different resource bases that required new social mechanisms and technologies to ensure long-term survivability, including the harnessing of fresh water through catchment, irrigation, and wells.

While it is perhaps not surprising that tubers played such a prominent role in the subsistence economies of islanders living in the Caribbean and Pacific given their domestication and widespread use in adjacent mainland areas, there were other important differences that set these regions apart in terms of farming and subsistence. The coconut, indigenous to the Indo-Pacific, was a critical source of food, water, oil, fuel, and raw materials for producing thatching and cordage; and because it was salt tolerant, could easily disperse over water without human intervention and/or brought in intentionally by colonizers. This important component of arboricultural systems in the Pacific was likely pivotal in the settlement of these islands, particularly those that were much more remote compared to anything seen in the Caribbean. In addition, the propensity for large scale earthworks, sophisticated systems for growing crops (e.g., terracing, irrigation, wet and dry field agriculture), and harvesting marine resources using fish ponds, for example, were all virtually unseen in the Antilles. Nonetheless, it is clear that populations in each of these major island regions developed subsistence strategies that were well maintained and highly productive, allowing peoples to sustain themselves extremely well for millennia.

In both the Caribbean and Pacific, domesticated and non-domesticated animals were translocated to and between the islands, some of which were integral parts of food production systems. In Remote Oceania, these included the dog, pig, chicken, and rat, though few islands ever had all four. The pig in particular appeared to have been extremely prized on some islands, but completely absent on others, with many cases of extirpation after initial introduction, especially on atolls (Giovas 2006). There is still some debate as to whether the rat was purposefully or accidentally introduced as it is an easy stowaway, though their ease of transport and high fecundity would have made them appealing to humans colonizing new and often biologically impoverished islands. Though the number of domesticated animals in the Pacific were few in number, they nonetheless were important and often played a major role in subsistence.

In contrast, the Caribbean saw many more animal taxa introduced than its much larger Pacific cousin, including guinea pig, armadillo, opossum, and agouti, along with skeletal fragments or elements of others such as jaguar teeth, paca, and deer. This is not entirely unexpected given the close proximity of the islands to surrounding mainland regions, particularly South America where these taxa originated. While it is not entirely clear whether some of these were brought in live or not, the widespread distribution of some (e.g., opossum, agouti), presence in pre-colonial midden deposits, and their continued presence

on many islands today, suggests that they were used as food. However, their numbers are typically much lower in archaeological sites than other native marine and terrestrial taxa, suggesting that Amerindian groups in the region did not incorporate them as a major component of their diet.

Overall, the Caribbean and Pacific exhibit some similarities in food production, with a heavy reliance on tuber crops supplemented with a suite of both native and exotic plants and animals. There are some distinct differences, however, in the level of technologies used, the impact these had on local ecologies, and how they influenced sociopolitical development across time and space. Continued research as to the antiquity, origin, and distribution of these various biota by island inhabitants will surely expand on our current understanding of how peoples in both regions subsisted for millennia, and open up critical new avenues of research.

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Part V

**Caribbean farmers
(methods and techniques)**



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9 Some methods for reconstructing the woody resources of Neolithic farmers in the Caribbean

Caroline R. Cartwright

Introduction

When considering how the beginnings of farming have established themselves in the Neolithic period, whether in Europe or the Caribbean, archaeologists and historians have often considered the possibility of dissemination from a primary epicenter. However, the transition from a hunter-gatherer way of life to a more sedentary one in which crops are grown, food security is established, livestock is managed sustainably, and the landscape is modified to suit the adoption of farming cultures, requires a more complex and nuanced modeling (for example, see Reid 2008, 2009; Siegel 2013). Whilst there may indeed have been pulses of migration of peoples around the Caribbean spreading ideas and techniques (for example, see Bérard 2004; Rodríguez Ramos et al. 2013), given the diversity of the Caribbean region, local innovations and developments cannot be excluded. Authors of other chapters in this volume (no doubt) will be considering the archaeological, bioarchaeological and chronological evidence for both inter-regional and local farming developments.

This chapter aims to outline the methods and objectives for determining, and the intrinsic potential for interpretation of, the woody resources of Neolithic farmers in the Caribbean, not only from the perspective of useful timber required for everyday living, but also considering wood and charcoal as proxy evidence for landscape and vegetational change over time, including as a result of land-clearance. Contingent upon the latter is recognition of the influential role played by both natural phenomena (such as lightning and hurricanes) in addition to broad-scale climatic changes; consequently, the physical evidence from archaeological sites and cores may sometimes be open to multiple or overlapping interpretations and, in some cases, predictive modeling in conjunction with other categories of evidence (for example, see Layman et al. 2010).

A significant area of research concerns arboriculture, which encompasses the selection, cultivation, and management of trees, shrubs, vines and other perennial woody plants by local communities. In order to sustain such resources, in practical terms this may involve planting, pruning, coppicing,

crown-thinning, fertilizing, controlling pests, irrigating where necessary, or relying on rain-fed systems. Newsom (1993), Newsom and Wing (2004) and Rodríguez Ramos (2010), for example, draw attention to the increasing importance of Ceramic-age arboriculture, particularly with regard to fruit-bearing trees. The development of arboriculture in the Caribbean must be considered alongside that of root-crop agriculture and home gardens as peoples adopt increasingly settled lifeways (see, for example, Keegan et al. 2013). Within the natural environment the successful balance of arboriculture and agriculture can stave off irreparable forest clearance and deforestation, but the archaeological and historical record demonstrates that this was not always the outcome.

As more Caribbean archaeological sites continue to be excavated, yielding charcoal and wood for identification and analysis, which can be interpreted alongside other botanical and ethnobiological evidence as well as faunal, molluscan, soil and artefactual details of the significance of farming and its impact on the natural vegetation can be reconstructed within a regional framework, as well as locally. Common factors such as rich fertile soils, adequate rainfall or available soil moisture, and sustained warm temperatures have encouraged the indigenous growth of diverse tropical vegetation, and then, over the millennia, the managed cultivation of tropical crops and their products. To what extent the successful achievement of farming or cultivation has impacted (negatively) on indigenous floras has yet to be fully investigated in all areas of the Caribbean.

The material evidence; methods of retrieval and analysis

Evidence for the presence of woody resources on archaeological sites can take a variety of forms. Amongst the most common is charcoal – burnt wood – that can survive in many different types of burial conditions on sites, including saline, wet or very dry (desiccated). Wood may also survive under particular forms of preservation where deterioration is slowed down, for example in waterlogged sites, in desiccated situations such as caves or anaerobic tombs, and as mineral-preserved (or mineral-replaced) organics associated with corrosion products on metalwork. All of these have positive and negative factors associated with their preservation and condition, and crucially, in the context of this particular chapter, their suitability for scientific analysis and identification (Cartwright 2015), as well as for radiocarbon dating (Brock et al. 2012; Ostapkowicz et al. 2013).

Charcoal can be extracted from archaeological sites by different methods such as wet or dry sieving/screening or flotation, hand-picking and bulk or core soil/sediment samples for laboratory processing. Each method has its advantages and disadvantages. The choice of one or a combination of these techniques depends on the nature of the site being excavated, the condition of the material and the availability of specialist expertise and laboratory facilities. Ideally, a wood scientist or anthracologist or archaeobotanist

would form part of the excavation or fieldwork project team from the outset. Such a specialist might be an active participant on site, or a consultant who follows through from retrieval of the evidence to its analysis and identification. In this way, and in consultation with the project team, a comprehensive interpretation and synthesis can be accomplished (Cartwright 1988, 2002, 2013; Drewett 1991). Charcoal extracted from excavated bulk soil samples is often subsampled prior to identification using a riffle box to avoid any bias towards selection of larger-sized pieces (Cartwright and Parkington 1997). Tiny flecks of charcoal sampled from cave paintings or rock art, such as those currently being analysed by the author for the Mona Island (Puerto Rico) El Corazón del Caribe research project directed by Jago Cooper and Alice Samson, as well as those from Cuba for Ruth Ann Armitage (also see Baker and Armitage 2013), need to be analysed in their entirety.

The retrieval or sampling of wood from archaeological sites is heavily dependent on the type of site being excavated, as the preservation of wood is far more variable than that of charcoal. If the site being excavated is entirely waterlogged, an on-site sampling procedure may need to be devised and implemented at the outset on account of the overwhelming quantity of material. As a general rule, however, most wood will need to be retrieved (from non-waterlogged sites) as it is likely to yield valuable information regarding the reasons for choice and selection of particular timbers for building, artefacts, fuel, ritual and ceremony. Archaeological wood may additionally be a source of information regarding coppicing or other forms of woodland management that could inform land-use practices within a Caribbean farming environment.

Whether it is charcoal or wood being analysed and identified, a reference collection of both is essential for accurate identifications in the laboratory stages. For optimal results, the wood anatomist should halve each securely identified wood specimen in order to make thin sections of one portion and convert the other half to charcoal using a laboratory kiln at a selected temperature. By this method useful data can be obtained regarding anatomical changes in different types of wood at specific temperatures (Leme et al. 2010) which, in turn, can provide comparative information for extrapolation when evaluating temperatures obtained by particular timbers within archaeological pottery kilns, domestic hearths/ovens, metal-working contexts, charcoal-burning clamps, ceremonial or funerary activities and even accidental burning of settlements. Although it is not always feasible to make thin sections of archaeological or historical specimens of wood that have been excavated, reference specimens are conventionally thin sectioned using standard microtome and staining techniques to provide transverse, radial longitudinal and tangential longitudinal sections (TS, RLS and TLS) of the wood (see Cartwright 2015). These are examined at a range of magnifications, usually from x50 to x500, using a transmitted light optical microscope or polarized light microscope.

For charcoal (reference specimens and archaeological material alike), and wood that cannot be thin sectioned, the best method for examining the anatomical features is to use scanning electron microscopy (SEM). For charcoal, the application of SEM rather than light (or optical) microscopy allows visualization of a better depth of field in the preserved cell structure, as well as having the capacity to offer high magnification imaging. Because of the three-dimensional nature of wood anatomy, each piece of charcoal, irrespective of size, needs to be fractured manually to show TS, RLS and TLS for examination (see Cartwright and Parkington 1997). When necessary, wood fragments (or samples) can be fractured using the same method to create TS, RLS and TLS. Whether it is charcoal or wood, it is vital to have all three sections available for interrogation as accurate scientific identifications cannot be achieved using just transverse sections (TS), or at low magnifications, or just consulting comparative images in books or on-line databases and wood atlases (undeniably essential as they are) illustrating textbook examples of modern reference wood specimens. It is advisable not to use a scalpel or razor blade to create the TS, RLS and TLS of charcoal, as this method creates fine dust as a result of the scalpel blade cutting into the fragment, and transfers it as infill into the cells, which renders identification difficult or impossible. Manual fracturing avoids this, and when carried out expertly, results in clean TS, RLS and TLS. To maximize cellular visibility, a refrigerant-based propellant cleaner (such as the proprietary brand “Dust-off”) can be used with caution. Similarly for wood, using a scalpel blade to create TS, RLS and TLS can produce a smudging of the cells that impedes identification. Where the wood condition permits, manual fracturing may be preferable. In the author’s experience, it is seldom desirable or feasible to embed wood or charcoal in resin for sectioning or grinding.

After fracturing, each TS, RLS and TLS charcoal (or wood) sample is then mounted onto an aluminium SEM stub for SEM examination using Leit-C Plast carbon cement (which is a proprietary brand of conductive material with low outgassing properties suitable for SEM use). As readers may find the details informative, an outline follows of some of the SEM methods that the author has used to identify charcoal over the last 30 years. Prior to 2007, charcoal and wood samples and reference specimens were identified using a JEOL JSM840 SEM in high vacuum (HV) mode, with an accelerating voltage of 20 kV. In this SEM, imaging of gold-coated TS, RLS and TLS was achieved using a scintillator backscattered electron (BSE) detector (K.E. Centaurus), offset from the electron beam axis to give topographic images with no charging effects. Selected areas were also examined through secondary electron (SE) imaging to show details of cell structures by carefully avoiding any charged areas. From 2007 onwards (including at the present day), TS, RLS and TLS of charcoal and wood specimens have been identified either using a variable pressure (VP) SEM, particularly if the samples are required for radiocarbon dating and thus must remain uncoated during the identification phase, or a field emission (FE) SEM. The VP-SEM used for uncoated

samples is the Hitachi S-3700N, mostly operated with the backscatter electron (BSE) detector, a probe current of 65.5, and an accelerating voltage of 15 kV. Occasionally, this may be raised to 20 kV or lowered to 12 kV, depending on the condition of the charcoal or wood fragment. For optimal visualization of diagnostic cellular detail, the working distance varies from 23 mm to 10 mm, as dictated by the individual specimen. For FE-SEM examination, after mounting, each stub with its charcoal or wood sample is sputter-coated with gold or platinum to make it conductive in the high vacuum conditions of the Hitachi S4800 FE-SEM using the SE detector, or BSE detector. In this FE-SEM, two complementary magnification modes are available: (1) low magnification at x30 to x2000; (2) high magnification at x100 to x800,000 and four objective lens apertures can be selected as required. The FE-SEM has the flexibility to achieve high resolution imaging of coated specimens with good contrast definition of surface cellular information, thus making it possible to identify very tiny charcoal flecks, and charcoal or wood in poor condition. In addition, on this particular model, the lower or upper detector signals can be selected to accentuate surface morphology and image contrast according to the detector position (see Cartwright 2013 for more details). The HV-SEM, FE-SEM and VP-SEM all have energy dispersive X-ray (EDX) spectrometry analysis capabilities, often used for wood to establish whether crystals in ray or axial parenchyma cells are calcium oxalate or silica.

Once identified, charcoal fragments are not counted; such a practice is meaningless, simply giving an index of fragmentation instead of a quantitative or semi-quantitative indicator of the presence or absence of different trees and shrubs (see Cartwright and Parkington 1997). However, in order to facilitate comparisons with results of charcoal identifications from other archaeological sites, it may be useful to summarize in tabular form the combined weight (in grams) of charcoal for each identified tree or shrub by context in the chronostratigraphic sequence. Before presenting any results in detail, it should be recognized that the individual presence of a single woody genus or species (tree or shrub) is relatively insignificant; associations of particular genera or species are far more meaningful and diagnostic when evaluating patterning over time. In consequence, it is preferable to discuss vegetational communities, rather than focusing on the presence or absence of a single taxon (i.e., a genus or species).

Interpretation

Whilst present-day vegetation data and maps of the Caribbean cannot be used as exact templates for assessing past vegetation cover, nonetheless they are essential reference for any reconstruction of past environments, particularly relating to geographical or topographical zones of woody resources that have been prone to over-exploitation or depletion in the past, either because (a) they have provided choice timber for building, artefacts and fuel;

or (b) they needed to be cleared to make room for cultivation or management of crops and other plant/animal products required for daily life and/or trade. It is clear that geographical, geomorphological, geological and tectonic history of the Caribbean has resulted in a wide diversity of habitats for woody trees and shrubs, some of which are (or were) endemic to specific locations, and many of which are very threatened (Areces-Mallea et al. 1999).

In many countries of the world, such as Australia and those in Africa (Tovar et al. 2014), regular widespread deliberate burning of vegetation takes place at the present day, not only as part of a regular agricultural cycle to prepare land in advance of renewed cultivation and create quantities of charcoal destined to be used as fuel, but also to stimulate sprouting of new growth of useful vegetation whose seeds are only released for germination through fire. It is not entirely clear to what extent there is direct evidence in the Caribbean region for such practices being a continuation of a tradition employed by Neolithic farmers, but any such documentation (League and Horn, 2000; Sara and Ortiz Aguilú 2003; Suman 1986) is extremely useful and valuable, not least because an increase in fire frequency may testify to deliberate human disturbance of the natural vegetation and landscape (Burney et al. 1994), although there may be other causes for such peaks in the record. Comparisons with evidence provided by pollen can assist greatly in any vegetational reconstruction (for example, see Islebe and Sánchez 2002).

For any evidence of a woody resource within an archaeological assemblage, consideration has to be given to the reasons for its presence. It may simply be the most common or readily gathered tree or shrub that is locally available. There is a strong possibility that it has been specifically selected because it is most suitable for firewood or fuel for a particular activity, or provides the kind of wood whose properties make it best suited for a certain type of artefact and function. Using woody shrubs (rather than trees) for fuelling local domestic fires is a pragmatic method for capitalizing on wood that is less suitable for artefacts or construction purposes. Such wood may be thorny, or has many branches or is not straight growing. However, if firewood is needed on a regular basis at sustained and predictable temperatures, such as for firing ceramics, metal-working activities and for village-based production of charcoal supplies, specific woody species will be needed that are of high calorific value. If these are used in close proximity to houses, it is advantageous if they have the capacity to burn without toxic smoke or sparks (Ayensu 1980).

Woody trees and shrubs are not just a source of useful timber, fuelwood and charcoal; some, such as *Bursera* spp. (copal trees) (Figure 9.1) and *Pinus* spp. (pines or torchwoods) (Figure 9.2) provide useful resin for incense and adhesives (McEwan et al. 2006; Stacey et al. 2006). Furthermore, trees and shrubs yield edible fruits, nuts, seeds, roots; leaves and branches for animal fodder; bark for fibres, tanning and dyeing. They may also be a source of hallucinogens, medicines and poisons. Managing the use of such valuable natural resources within local farming communities across the Caribbean

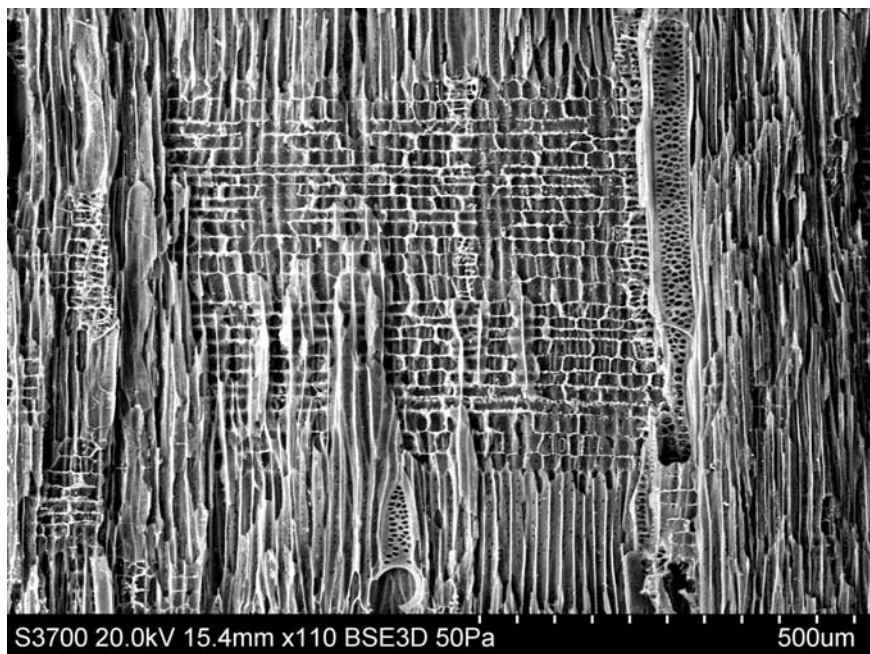


Figure 9.1 Variable pressure scanning electron microscope (VP-SEM) image of a radial longitudinal section of *Bursera simaruba* (gumbo-limbo) charcoal. Image: Caroline R. Cartwright © The British Museum.

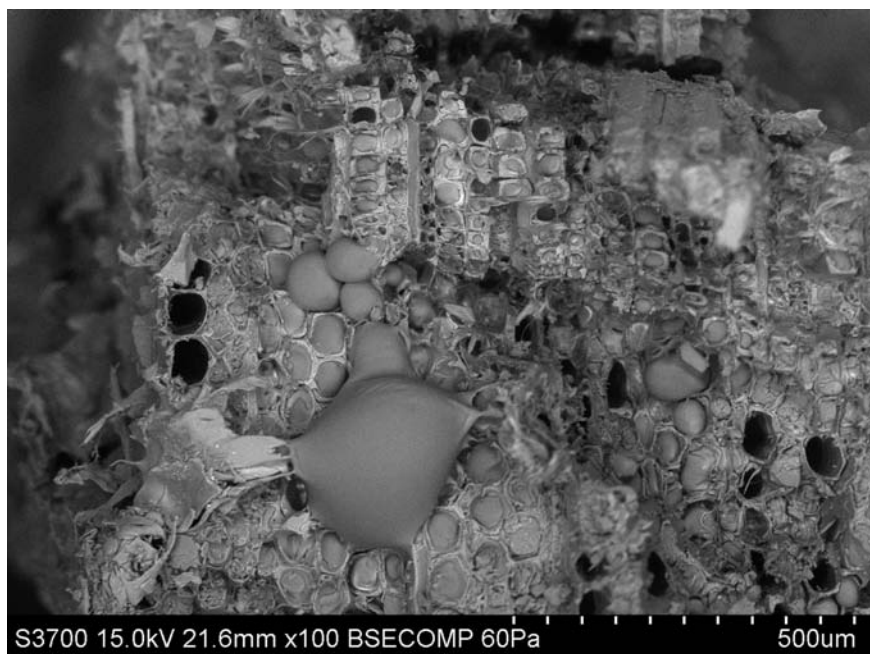


Figure 9.2 VP-SEM image of a transverse section of *Pinus* sp. (pine) wood showing resin oozing from the resin canals. Image: Caroline R. Cartwright © The British Museum.

region was likely to have been as important as creating opportunities for sustained (or opportunistic) cultivation of crops. Clearly, the useful timber and edible or utilitarian products offered by the trees themselves were of prime importance, but equally vital to note is the fact that trees and shrubs in different vegetation zones across the Caribbean provided niche habitats for a rich diversity of animals, birds and insects, many of which played a part in the diet, accoutrements and lifestyles of people (also see Reid 2009).

It is worth considering to what extent many farming households would have relied on the local production of charcoal for domestic fuel as well as for particular activities such as creating cave pictographs, and it seems unlikely (not least on account of the time and effort involved) that large, useful trees such as *Hymenaea courbaril* (guapinol or jatobá tree) or *Pithecellobium arboreum* (quebracho) would have been completely felled for such purposes (see Cartwright in Baker and Armitage 2013: 320–321). One may consider whether there were forms of sustainable resource management such as pruning, or the collection of fallen (dead) wood when exploiting many of the prime tropical trees. Where possible, utilizing woody shrubs (or trees) that grow easily, require little attention and that can adapt well to a wide range of different or even problem environments could assist in protecting over-exploitation of the prime timbers. However, an uncomfortable 20th-century statistic asserts that about 200 million people living in or near humid tropical forests need to fell acres of trees each year to satisfy their daily fuelwood and charcoal requirements (Ayensu 1983: 2). This may mean that in the past, scavenging fallen branches and exercising some woodland management may not have provided a sufficient or sustainable form of resource management for Caribbean farmers (although it is acknowledged that it is impossible to generalize for the entire Caribbean). Furthermore, cultural or trading priorities may have outweighed preservation of some important woody resources, potentially endangering or over-exploiting sought-after timbers such as *Cedrela odorata* (red ‘cedar’) (Figure 9.3), *Guaiacum officinale* (lignum-vitae) (Figure 9.4), *Amyris elemifera* (sea torchwood or cuabilla) (Figure 9.5), *Swietenia mahagoni* (West Indian mahogany) (for example, see Young 2008) and *Ceiba pentandra* (silk-cotton tree), which was highly valued by native groups in the Caribbean (for example, see Saunders 2005: 289).

In terms of environmental reconstruction of woody resources over time, it is important to note that charcoal is present on any archaeological site as a result of many different factors, including anthropogenic, taphonomic and incidental. Some specialists may consider that selection of specific fuelwood by people could account for a high (and perhaps even the highest) proportion of charcoal excavated and retrieved, and that different trees or shrubs represented by the charcoal should never be directly interpreted in proportional terms as exact reflections of the surrounding (local) environment. Relevant to this theory is the possibility that many varieties of trees or shrubs could have been selected from considerable distances away from the archaeological site, whilst collecting other non-woody resources such as

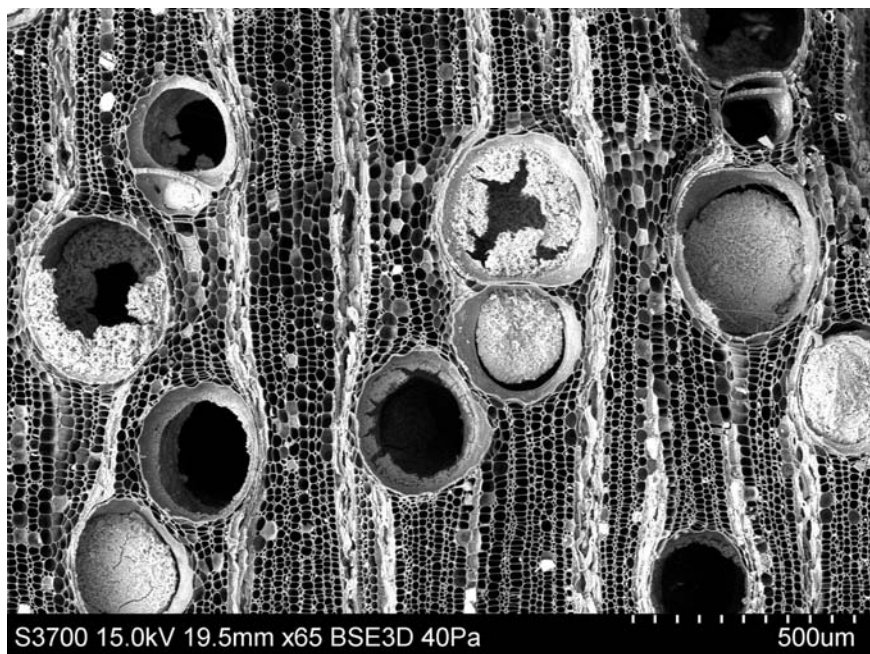


Figure 9.3 VP-SEM image of a transverse section of *Cedrela odorata* (red 'cedar') charcoal. Image: Caroline R. Cartwright © The British Museum.

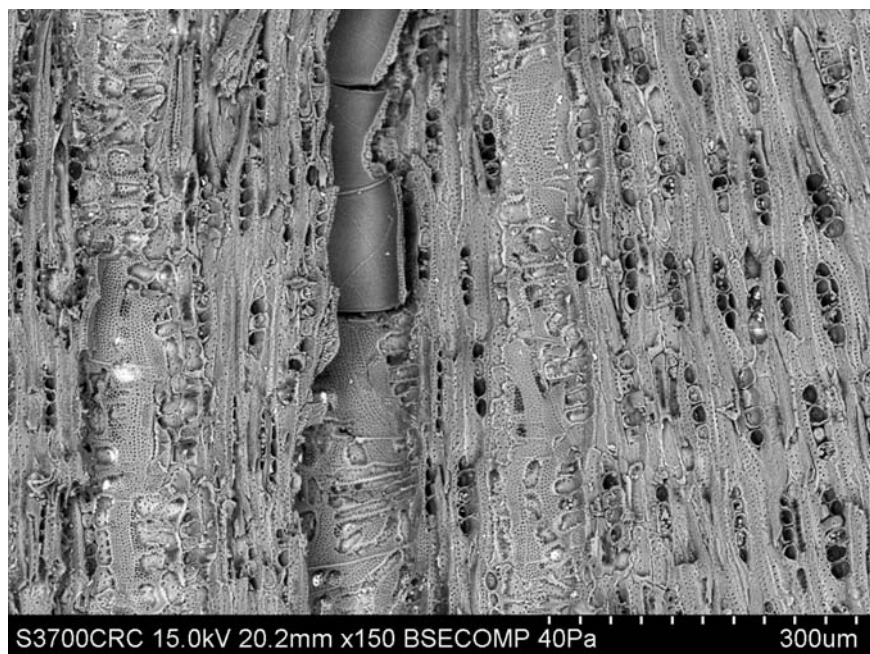


Figure 9.4 VP-SEM image of a tangential longitudinal section of *Guaiacum officinale* (lignum-vitae) wood. Image: Caroline R. Cartwright © The British Museum.

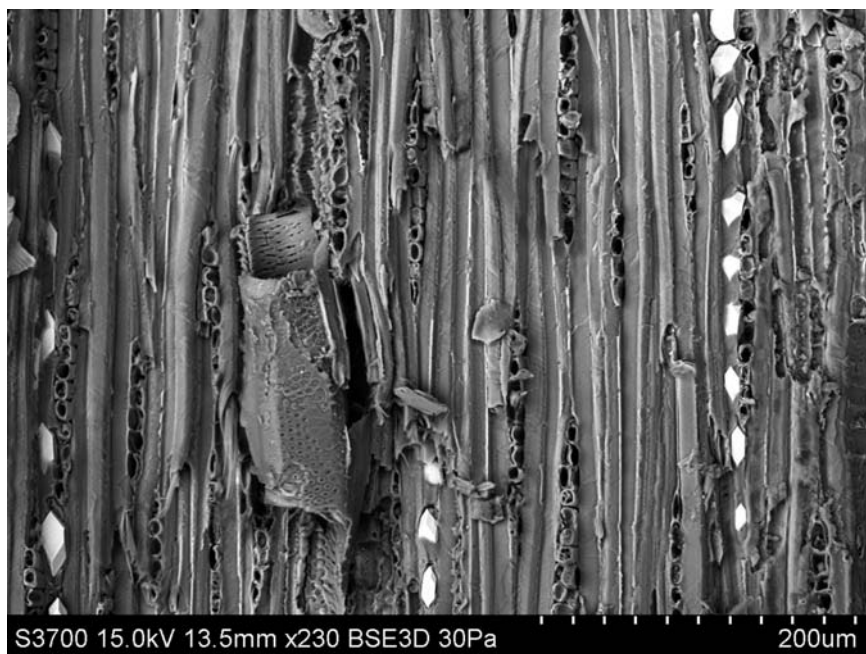


Figure 9.5 VP-SEM image of a tangential longitudinal section of *Amyris elemifera* (sea torchwood or cuabilla) wood. Image: Caroline R. Cartwright © The British Museum.

stone, shell and ochre. Another viewpoint presents the case that as the charcoal-rich sediments on certain archaeological sites may have accumulated over a very long time period, it is plausible to suggest that associated climate change accounts for most of the differences in vegetation. This argument predicates on the widely held view that people (and hunter gatherers in particular) mainly acquired their resources within a few hours (or about 10 km) walk from their base (Cartwright 2013).

Future objectives

Establishing the links within the Caribbean (and Mesoamerica) between human occupation, climate change and impact on land-use and vegetation are perhaps amongst the most interesting areas of future research, which can build on existing publications (such as Cooper 2013; Cooper and Peros 2010; Hodell et al. 1991, 1995, to mention just a few). Such research does not rely solely on the evidence of woody resources but of many other forms of data from the botanical, bioarchaeological and isotopic repertoire (such as Kooyman 2005; Newsom 2006; Newsom and Pearsall 2003; Newsom

and Wing 2004, amongst others). Through such research it will be possible to evaluate more comprehensively the impact of farming peoples in their quest for settlement stability, sustainable food procurement and the capacity for food surplus storage, against the framework of reference of the impact of any climatic change. An important subset of the broad research topic relates to the dynamics of the smaller islands within the Caribbean, which Keegan et al. (2008) describe as having access to resources and landscapes not always readily available on the larger islands.

Present-day vegetation classification and vegetation mapping in the Caribbean region continue to provide challenges inasmuch as there are many types of landscapes with high variability and degrees of endemism. As different classification systems describe the vegetation of larger individual islands (such as Cuba and Jamaica) or smaller groups of islands (e.g. Trinidad and Tobago, the Bahamas, and the US Virgin Islands/Puerto Rico), it remains problematic to synthesize such information for the entire Caribbean (Acevedo-Rodriguez and Strong 2008; Areces-Mallea et al. 1999; Farjon and Filer 2013; Santiago-Valentin and Olmstead 2004). The 104 Caribbean vegetation formations described by Areces-Mallea et al. (1999) include many variable subset categories of rain and cloud forests; seasonal evergreen or deciduous forests; mangroves; plantation forests and woodlands; open tree canopy evergreen or deciduous woodlands; xeromorphic forests, woodlands and shrublands; thorn woodland; shrublands; grasslands, sometimes with evergreen, deciduous or xeromorphic trees, dwarf shrubs, herbaceous flowering plants (forbs) or succulents; swamp, aquatic, cliff, talus, dune, strand and mud-flat vegetation. It follows, therefore, that any attempt towards a Caribbean-wide extrapolation back through time for reconstructing the biogeographical exploitation of woody resources in former farming communities will require much future collaborative work. In some areas of the Caribbean only remnants survive of some of the woody components of these vegetation formations, mostly in less accessible locations unsuitable for agriculture. In other regions of the world it has been demonstrated that detailed present-day local mapping of all woody taxa present in an archaeological sequence has been crucial for presenting a resolved palaeoenvironmental and phytogeographical reconstruction through time (Cartwright 2013), but such research outcomes are markedly dependent on the availability of, and access to, particular categories of archaeological sequences, as well as a specialist team with sufficient resources and time to undertake the work locally.

Whilst the use of a reflected light optical microscope providing a range of high magnifications will remain the 'workhorse' method for identifying the bulk of archaeological charcoal assemblages (including samples prior to submission for radiocarbon dating), the application of SEM to the analysis of archaeological charcoal and wood has revolutionized the identification process and the anatomical documentation of taxa, particularly for tiny or poorly preserved fragments. The SEM has enabled charcoal and wood to be

examined with considerably higher magnifications, greater clarity, definition and precision than is possible with an optical microscope. Furthermore, it has significantly enhanced the production of high quality, diagnostic images of the cellular structure at species level. Not only has this increased the frequency and accuracy of identification of species, sometimes it has revealed details of the history of the individual tree or shrub in the form of damage, pith flecks or environmental stress. Such fine details can assist in future stages of research that might focus directly on the reconstruction of palaeoenvironmental or climatic conditions on a local as well as regional scale. In order to understand the mechanisms underlying changes in the composition of vegetation reflecting the use of woody resources over time, careful consideration has to be given at each chronological phase to weigh up technological change (particularly in the stone tool assemblages) alongside differences in the diversity and composition of vegetational communities governed by ecological tolerances. Crucial to such considerations are woody trees and shrubs that are highly sensitive to environmental change and are therefore good indicators. Useful comparative data may also be gleaned from present-day vegetational evaluations that show a mosaic of communities, some isolated (in vegetational terms) from others on account of the parent geology, soils and responses to changing availability of soil moisture over time.

At the time of writing, there is a profound change in the way that science is carried out, and whilst new discoveries by individual scientists of long-standing reputation and authority continue to make vital contributions to the scientific community, it is also beneficial for institutions to form effective international partnerships with strategic priorities in order to share the investigation of major scientific projects so that irreplaceable data can be extracted and recorded for posterity about our ever-increasingly threatened archaeological and environmental heritage. Combining information, expertise, vision and new technologies could also provide wider opportunities for directly engaging the public with the ideas and results of science, ultimately inspiring a greater understanding of the natural world, and critical societal challenges common to all people, such as environmental sustainability, biodiversity loss and climate change.

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10 Domesticating the island

Anthropogenic soils and landform modification as components of subsistence- resource acquisition strategies in Puerto Rico

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Introduction

Humans act within space. As people move and act over geographical areas, space is reinterpreted into a social conceptualization of experiences and distribution of resources that humanize the geomorphology (Balée and Erickson 2006; Erickson 2008, 2010; Hayashida 2005). Landscapes are a social construct (Knapp and Ashmore 1999). This idea has been developed using the concept of ‘landscape domestication’ which proposes that all practices and human activities transform the environment, intentionally or not, eventually reshaping its characteristics in a way that is particularly beneficial for humans (Balée and Erickson 2006; Delle 1998; Erickson 2008; Terrell et al. 2003). People’s decision-making, experiences and interpretations accumulate through time and are transmitted as part of traditional and local knowledge (Balée and Erickson 2006). As historical ecology and niche construction theory explain, landscapes also physically reflect the accumulation of conceptual structures of the societies living on them (Balée 2006; Kendal et al. 2011; Lehmann et al. 2003; Smith 2012).

On islands and continental coastal zones, those domesticated and socialized spaces are not limited to the land, but also extend into the sea and adjacent terrains: the aquapelago or the continent divided by water as Torres and Rodríguez Ramos explain it (Hayward 2012a; Torres and Rodríguez Ramos 2008). The term ‘aquapelago’ was introduced by Hayward (2012a, 2012b) to address the way in which human experiences integrate islands and their adjacent waters and seafloors, constituting a contextualized social unit. Within it, “aquatic spaces are utilized and navigated in a manner that is interconnected and essential to the social group’s habitation of the land and their senses of identity and belonging” (Hayward 2012b: 4; see also Westerdahl 1992). Aquapelagos are entities created when humans occupy and interact with integrated island and aquatic spaces, and do not exist without human presence and human connectivities of island-water spaces

(Hayward 2012a: 2). Therefore, islands cannot be studied in isolation (Stratford et al. 2011), but have to be contextualized within the social processes occurring around them (Arnaud 2008; Curet 2004). In the Caribbean archipelago, case studies from a variety of contexts suggest multiple, sustained and interwoven contacts and exchange between the Antilles, the southern Caribbean and the lower Central America (Hofman et al. 2010, 2014; Laffoon et al. 2014). Together with material goods, ideas and practices were also transmitted along complex long- and short-distance webs of interaction (Hofman and Bright 2010). One of the ideas that moved along with people is the knowledge of what to eat and how to procure it.

Subsistence as traditional knowledge

As part of the material culture of societies, food consumption can reflect identity and relationships of power (Twiss 2015). Strategies for food procurement, therefore, are directly linked to the consumption of food – and thus to identity – and become particularly important under migratory contexts where identities are displaced and relocated, but look to be reinforced and redefined through new and continued practices that reinforce and display cultural identification (Fischler 1988; Ortiz-Cuadra 2003; Rabikowska 2010; Scott 2008; Twiss 2012). Subsistence-resource acquisition can be comprised of a wide range of strategies, such as hunting, gathering, herding, fishing, horticulture, arboriculture and agriculture. These strategies are not mutually exclusive and can occur simultaneously, complementing one another.

Soils are an important component of the natural environment, and of the landscape as an anthropic artefact. Soils form on surfaces after deposited sediments (or parent material) have remained stable at a location for a considerable amount of time and have been subject to weathering and to the development of biogenic processes, including bacterial activity, and plant and animal colonization. These changes alter the characteristics of the sediment, enhancing dissolved and particulate organic matter, as well as nutrient availability for plant growth. From an ecological perspective, soils are the interphase on which the continuity of the ecosystem life-cycle is based.

Intentional and unintentional human activities affect soil formation, particularly through organic and inorganic refuse disposal, and interference with local flora and fauna living on the surface and shallow sub-surface of the land. Soil types whose physical and chemical properties, including parent material, are regulated by human activities are known as anthropic soils (Canarache et al. 2006: 59; Capra et al. 2015; ICOMANTH 2011; Soil Survey Staff 2014). Two main types of anthropic soils are identified in archaeological studies: dark earth (Nicosia and Devos 2014) and Amazonian dark earths (ADE) (*Terra Preta* and *Terra Mulata*) (Arroyo-Kalin 2014). While dark earth is usually found in urban settings, ADE have been identified and discussed in Neotropical contexts associated to intense forest settlement and agriculture (Arroyo-Kalin et al. 2009; Graham 1998; Neves et al. 2003).

Initially identified in the Central and Northern Amazon, ADE are organically enriched soils found in circumscribed expanses in direct association to archaeological sites in the Amazon basin. The *terra preta* are black or very dark deposits showing a deep A horizon, often over 60 cm deep. They also contain very high density of artefacts, in particular ceramics and other materials such as bones, fish scales, shell and charcoal, and are characterized by high content of organic matter, phosphates and other micronutrients (Arroyo-Kalin 2014; Eden et al. 1984; Erickson 2008; Lima et al. 2002; Woods et al. 2009). In contrast, *terra mulata* is less dark and has much lower phosphate content, showing levels similar to the background soils. It usually has less density of domestic refuse and archaeological materials, but has higher percent of organic material than the *terra preta* (Kampf et al. 2003). Scholars have generally associated the *terra preta* with on-site formation of anthropic soils formed under permanent settlements with high density of occupation, while the *terra mulata* formed on the area around the sites, on the outfields of settlements (Arroyo-Kalin 2014). The alterations made to soils at different locations throughout the Amazonian region testify to traditional ecological knowledge about soil management.

Being part of the wider Neotropical knowledge network that incorporated the use of particular plant assemblages, we can expect that the groups in the Caribbean archipelago would have also utilized the traditional ecological knowledge linked to agricultural or plant-management practices. If anthroposols are the pedogenic product of human activity over land surfaces under particular climatic and environmental conditions, there is every reason to expect that soils similar to ADE could also have formed throughout the Caribbean Lowlands (Graham 1998, 2006).

Case studies

In order to test how human activity is reflected on the microlandscape, we selected two sites in Puerto Rico: Angostura and Salto Arriba (Figure 10.1).

Angostura (labeled b. in Figure 10.1) is located at the piedmont of the karst region, within the municipality of Barceloneta. The total extension of the site has not been identified. The northern section of the site was destroyed by the construction of a shopping mall, and part of the southern section was fully excavated for the construction of the highway. The site is characterized by four mounds, marked as A, B, C and D. The discussion in this chapter focuses on sediment samples from Units 1, 3 and 4. Angostura (Figure 10.1) is a settlement of the Archaic Period, inhabited between 4.4k and 2.2k cal BP (2400–200 cal BC), and probably continuing later. The site is characterized by the presence of four mounds of accumulated anthropogenic layers over natural rocky outcrops. The area today lies about 5 km from the sea shore, but in the past it was near (ca. 500 m) the shore of the Paleo Tiburones Lagoon (Rivera-Collazo 2011a). The site, located at the foothills of the karst range by the Rio Grande de Manati floodplain, was initially discovered by Ayes in the

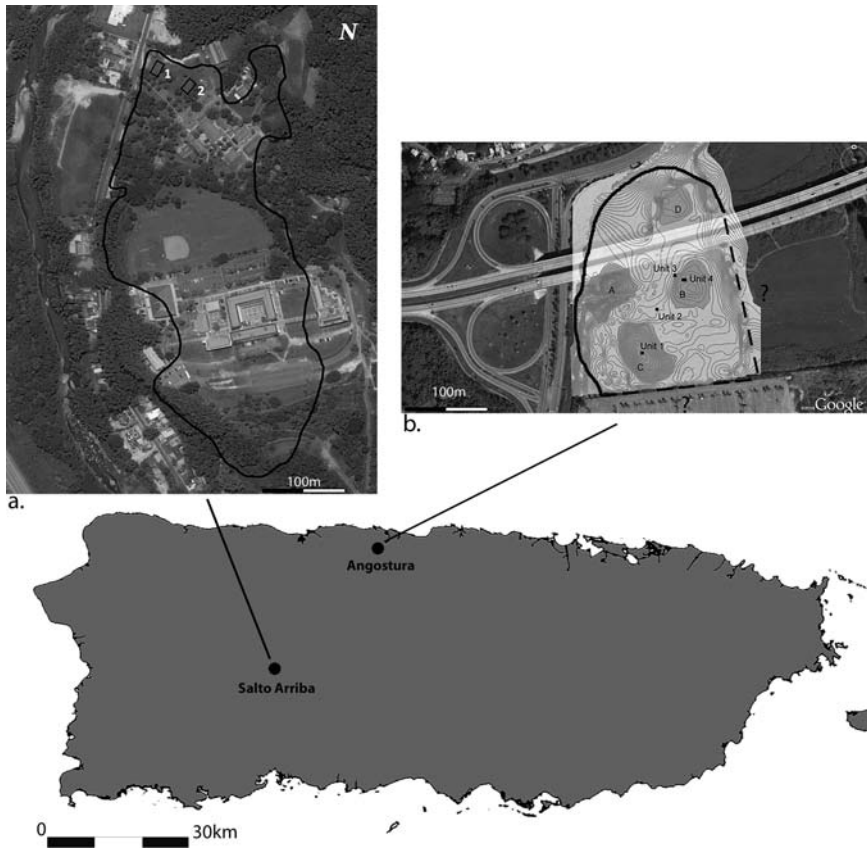


Figure 10.1 Map of Puerto Rico showing the location and zoomed images, in the same scale, of Salto Arriba and Angostura. (Produced by I. Rivera-Collazo).

1980s and was re-excavated in 2008 by Rivera-Collazo. Geoarchaeological and paleo-climatological analyses of the site and its environmental context have been published elsewhere (Rivera-Collazo 2011b; Rivera-Collazo et al. 2015) and will be re-examined in this chapter (see Figure 10.2 and Table 10.1). The samples were collected during the 2008 excavation season, and correspond to the sampling of all identified strata from Units 1, 3 and 4. Units 1 and 4 are located over the mounds (Mounds C and B respectively) and consist of mostly anthropogenic and habitation layers. Unit 3 is adjacent to Mound B and consists of a uniformly black deposit of sediments with relatively high density of microartefacts but low (macro) artefact content.

Salto Arriba (labeled a. in Figure 10.1) is located on the mountainous region of Puerto Rico, within the municipality of Utuado. Most of the site

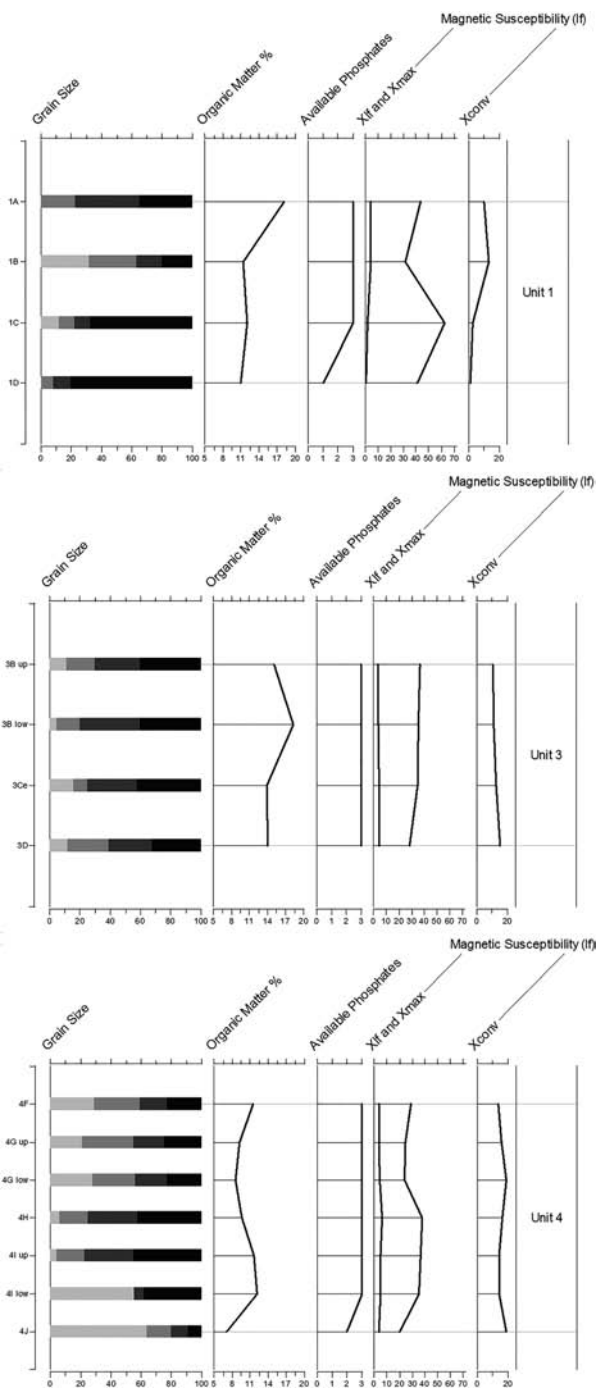


Figure 10.2 Graphs summarizing the results of the geoarchaeological analyses for Units 1, 3 and 4 of Angostura. The results are discussed in the text. (Produced by I. Rivera-Collazo).

Table 10.1 Results from the multi-fraction microartefact analysis of Angostura, Units 1, 3 and 4. Each group of rows represents the grain size fractions of a single sample (4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm)

UNIT/STRAT	FRACTION SIZE	Char.	Microlithics	Ceram.	Bone	Shell	Insect
1B	4 mm					98	
	2 mm				5	90	
	1 mm	0.5			20	73.5	
	0.5 mm	8			15	72	
	0.25 mm	9			5	20	
	0.125 mm	19			2	15	
1C	4 mm					80	
	2 mm	2.5			20	75	
	1 mm	10				30	
	0.5 mm	6			1	13	
	0.25 mm	4			1	10	
	0.125 mm	3			traces	2	
3C _{MIDDLE}	4 mm		10	40		40	
	2 mm	5	1		4	60	
	1 mm	2			35	50	
	0.5 mm	1.5			55	35	
	0.25 mm	6			4	4	
	0.125 mm	9			3	4	
3C _{EAST}	4 mm		95			5	
	2 mm		2		70	28	
	1 mm	9	1		50	40	
	0.5 mm	3	1		60	30	
	0.25 mm	10			30	25	traces
	0.125 mm	1			5	3	
3D	4 mm		15		20	60	
	2 mm	1	1		11	85	
	1 mm	5	2		21	64	
	0.5 mm	3			15	78	
	0.25 mm	10			21	41	
	0.125 mm	3			10	22	
4G _L	4 mm				0.2	99.8	
	2 mm				1	98	
	1 mm				8	90	
	0.5 mm	5			15	39	5
	0.25 mm						
	0.125 mm	3			10	18	
4H	4 mm					100	
	2 mm				30	60	
	1 mm	1.5			45	45	1
	0.5 mm	3			28.5	39	1
	0.25 mm	5			9	12	1
	0.125 mm	6			5	3	1
4I _U	4 mm					90	
	2 mm				30	60	

(Continued)

Table 10.1 (continued)

UNIT/STRAT	FRACTION SIZE	Char.	Microlithics	Ceram.	Bone	Shell	Insect
4J	1 mm	5			20	60	
	0.5 mm	7			12	20	
	0.25 mm	6			13	11	
	0.125 mm	7			1	2	2
	4 mm					100	
	2 mm				4	95	
	1 mm				3	95	
	0.5 mm				6	92	
	0.25 mm	2			5	85	
	0.125 mm	11			1	40	3

was severely impacted by the construction of the Utuado Campus of the University of Puerto Rico, and the road PR-123. The study area is labeled with numbers. Number 1 marks the location of Section B, where Unit 13 was excavated next to a batey or ballcourt. Number 2 marks the location of Section A, where Unit 2 was excavated, sampling a dark sediment feature buried under alluvium. Salto Arriba (Figure 10.1), located on the premises of what is today the University of Puerto Rico, Utuado Campus (UPRU), is an extensive settlement of the Agro-Ceramic Age (AD 700–1360 [1315– 655 cal BP]). The site extends through the west margin of the Rio Grande de Arecibo, demarcated by the Quebrada Arenas on the north, and on the south by the Road PR-123 and the Rio Grande de Arecibo (Rodríguez Ramos 2014). Salto Arriba was initially identified and explored by Fewkes and Rouse during the first half of the 20th century, and was later intensively intervened (and mostly destroyed) during CRM and development projects, including construction of the PR-123 and the UPRU facilities in the 1990s. As of 2011, Rodríguez Ramos continued excavating less impacted areas of the site as part of his UPRU archaeology research program. One of the most interesting aspects about Salto Arriba is the plurality present in the same stratigraphic contexts, particularly the combination of multiple ceramic styles of Saladoid and Ostionoid traditions during the period before AD 1000–1100 (Rodríguez Ramos 2014). Rodríguez Ramos argues that this characteristic calls for a reconceptualization of the relationships of the groups inhabiting the mountainous region at that time.

The samples analyzed for this chapter (see Figure 10.3 and Table 10.2) were obtained between 2011 and 2014 from sections A and B of the site. Section A (Unit 2) is located to the east of Section B. It is characterized by multiple post mold features and particularly by a thick dark sediment feature (Samples 9–11) buried under alluvium. Section B corresponds to an area where habitational and ballcourt (batey) features were identified. The samples were retrieved from the profile of Unit 13, at the edge of the batey and sampled through the batey’s floor (samples 16 and 17).

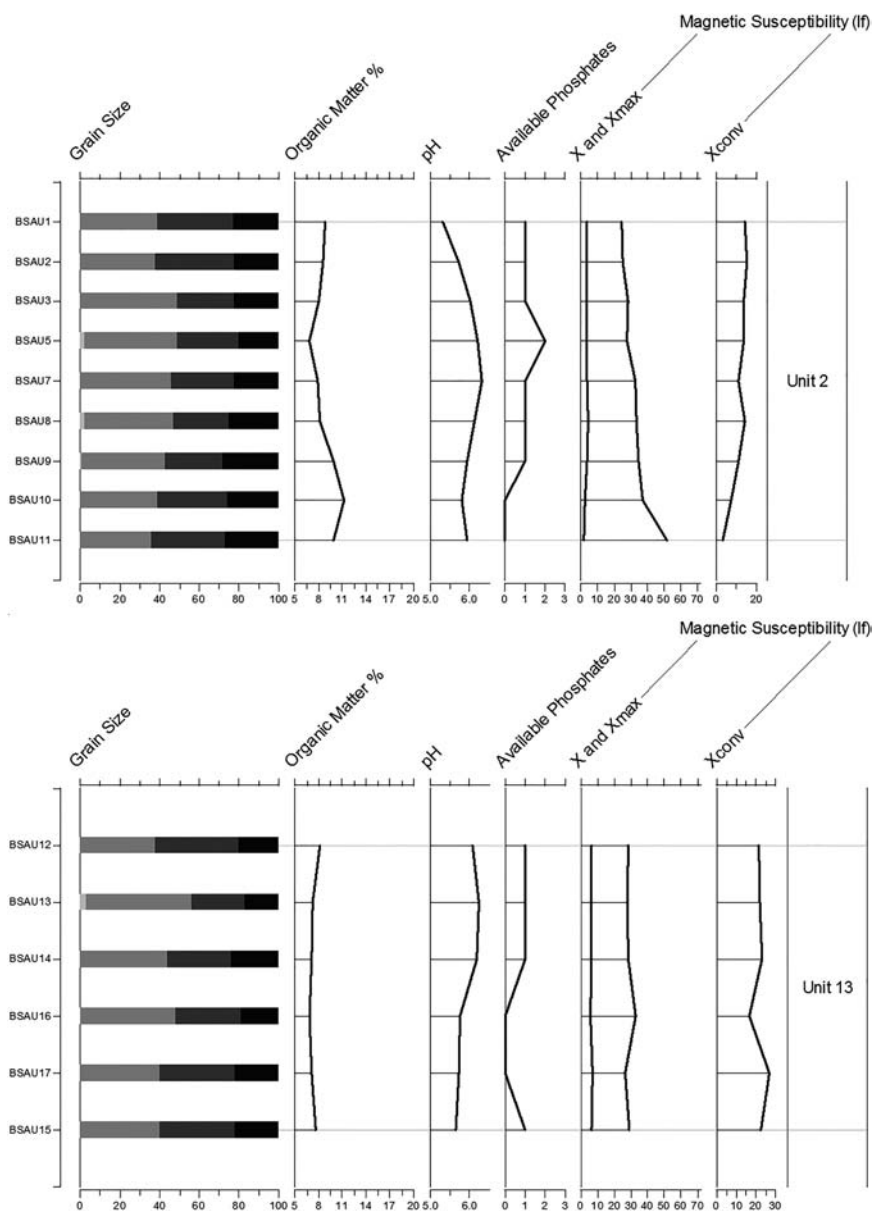


Figure 10.3 Graphs summarizing the results of the geoarchaeological analyses for Units 2 and 13 of Salto Arriba. The results are discussed in the text. (Produced by I. Rivera-Collazo).

Table 10.2 Results from the multi-fraction microartefact analysis of Salto Arriba, Units 2 and 13. Each group of rows represents the grain size fractions of a single sample (4 mm, 2 mm, 1 mm, 0.5 mm, 0.25 mm, 0.125 mm)

<i>Unit/level</i>	<i>Fraction size</i>	<i>Char.</i>	<i>Microlithics</i>	<i>Ceram.</i>	<i>Bone</i>	<i>Shell</i>	<i>Insect</i>
2/2 BSAU3	2 mm						
	1 mm	traces					
	0.5 mm	traces					
	0.25 mm	traces					
2/3-1 BSAU5	0.125 mm	traces					
	2 mm						
	1 mm	0.5					
	0.5 mm	traces					
2/3-2 BSAU7	0.25 mm	traces					
	0.125 mm	traces					
	2 mm		5				
	1 mm						
2/4-1 BSAU8	0.5 mm	0.5					
	0.25 mm	traces					
	0.125 mm	traces					
	2 mm						
2/5-1 BSAU9	1 mm	traces	traces	traces			
	0.5 mm	1	traces	traces			
	0.25 mm	1.5		traces			traces
	0.125 mm	2		traces			traces
2/5-2 BSAU10	2 mm						
	1 mm	traces					
	0.5 mm	traces	traces	traces			
	0.25 mm	traces					
2/6-1 BSAU11	0.125 mm	1					
	2 mm						
	1 mm						
	0.5 mm	traces					
13/B-1 BSAU12	0.25 mm	traces					
	0.125 mm	traces					
	2 mm						
	1 mm						
13/B-2 BSAU13	0.5 mm	traces					traces
	0.25 mm	traces					
	0.125 mm	traces					
	2 mm		2				
13/B-2 BSAU13	1 mm	traces	traces				
	0.5 mm	traces					
	0.25 mm	traces					
	0.125 mm	traces					

Table 10.2 (continued)

<i>Unit/level</i>	<i>Fraction size</i>	<i>Char.</i>	<i>Microlithics</i>	<i>Ceram.</i>	<i>Bone</i>	<i>Shell</i>	<i>Insect</i>
13/C-1	2 mm	7					
BSAU14	1 mm	5	5	5			
	0.5 mm	2					
	0.25 mm	1					
	0.125 mm	0.5					
13/D-1	4 mm		n=1				
BSAU16	2 mm	5	5				
	1 mm	4	traces	1			
	0.5 mm	1		traces			
	0.25 mm	2					
	0.125 mm	traces					
13/D-2	2 mm	10	5				
BSAU17	1 mm	9	traces	1			
	0.5 mm	1					
	0.25 mm	0.5					
	0.125 mm	0.5					
13/E-1	2 mm	15		25			
BSAU15	1 mm	8	5	7			
	0.5 mm	5					
	0.25 mm	traces					
	0.125 mm	traces					

These sites represent different periods of the pre-Columbian history of Puerto Rico: the Archaic and the Agro-Ceramic Ages. Even though initially conceptualized as traditional hunter-gatherers, the subsistence strategies of the Archaic Age have recently been expanded to include horticulture and arboriculture, including the consumption of domestic cultivars, as seen from the presence of starches in tools (Rodríguez Ramos and Pagán Jiménez 2007; Pagán Jiménez 2007, 2011). Agro-ceramists, as the name suggests, are defined as having subsistence strategies based on agriculture of multiple crops, including cassava, maize, legumes, chilies and others (Pagán Jiménez 2007; Pagán Jiménez et al. 2005). While the protein aspect of the diet was obviously complemented with hunting of wild resources, the role of this important subsistence activity within a broadly agricultural / horticultural economy is seldom emphasized.

Laboratory methods

All laboratory analyses were conducted at the Environmental Archaeology Laboratory of the University of Puerto Rico, Rio Piedras Campus. Geoarchaeological methods were applied to evaluate the sediments. Tests included grain size analysis, organic loss on ignition, pH, phosphate content, magnetic susceptibility and microartefact analysis. Grain size was determined combining the hydrometer and dry sieving methods. Approximately 30 g of

sediment was combined with 50 ml of a 5% sodium hexametaphosphate ($(\text{NaPO}_3)_6$) solution and disaggregated in water to form a 1000 ml column. The density of suspended fine-grain sediments was measured using hydrometers and calibrated against a control cylinder. Measurements were taken at specific intervals for 24 hours. The grain particle distribution of the coarse fraction was calculated by weight after dry sieving. The coarse fraction was retained and observed under the microscope to examine mineralogical composition and microartefact content per sediment fraction.

Organic content of the sample was calculated using the loss on ignition method. For the organic content, 10 g of sediment were burnt in a muffle furnace at 550°C for 1.5 hours and left to cool in the chamber. The percentage of organic matter was calculated by registering the difference in sample weight before and after burning. Phosphate content was determined using the colorimetric Gundlach method. Approximately 0.5 g of sediment was placed on an ash-free filter paper. To extract the phosphate, two drops of ammonium molybdate solution (30 ml 5 N HCl to 5 g of ammonium molybdate dissolved in 100 ml of cold distilled water) were added to the sample, followed 30 seconds later by 2 drops of ascorbic acid (1 g of ascorbic acid dissolved in 200 ml of distilled water). Observations of blue color dispersion in a visual scale of 0–3 (0= no reaction, 3=strong blue radiating bands) were made after a standard timeline of 2 minutes, given that color continues developing as long as the sample is not neutralized.

Magnetic susceptibility (χ) was measured using a Bartington MS2 meter for Angostura and an MS3 meter for Salto Arriba, both with an MS2B sensor. For all samples, 10 g of sediment were placed in diamagnetic containers and readings were made in low and high frequencies according to the standard protocols of each meter. Ferrimagnetic minerals can form after deposition as a result of burning or due to the alternating reduction/oxidation conditions associated with pedogenesis. Therefore, the degree of enhancement, or fractional conversion (χ_{conv}), of the particular samples should be determined. Enhanced samples can be diagnostic of paleosols or anthropogenic activity such as burning. Fractional conversion is obtained by calculating the ratio of the normal reaction of a sample (χ_{LF}) to its maximum potential (χ_{max}), which is obtained by subjecting the sample to a cycle of reducing and oxidizing conditions in the laboratory (Crowther 2003). This was achieved by placing 10 g of dry sample in 25 ml porcelain crucibles, mixed with 1 g of plain flour, and fired with lids and closed furnace chimney at 650°C for one hour. This cycle creates an anoxic firing environment. After 20 minutes, the furnace door is opened, the furnace chimney opened, the lids removed, and the samples are run for an additional 45 minutes after reaching optimal temperature, when the oven is turned off. The oven door is opened to ensure that the chamber contains a high-oxygen atmosphere during the cooling period (Clark 1996). After cooling, the samples are again placed in diamagnetic containers and their maximum magnetic potential is measured.

Results and discussion

Angostura

The results are summarized in Figure 10.2 and Table 10.1. The graphs presented in Figure 10.2 show grain size percentage divided, from left to right (lighter to darker colors) in pebble, sand, silt and clay content. Organic matter is also presented as the percentage of content per weight of sample. Phosphates are shown in a scale of 0–3 (see text for explanation). Magnetic susceptibility shows low frequency (χ_{lf}) and maximum potential (χ_{max}) together within one graph, and the fractional conversion (χ_{conv}) in the last graph, illustrating the relationship between χ_{lf} and χ_{max} . The results from Angostura and Salto Arriba are in the same scale to facilitate comparison between records. The results of the microartefact analysis are shown in Table 10.1. The column to the left marks the unit and the stratum analyzed. Observed microartefacts include charcoal (burnt seed/fruit, wood and other organics), microlithics, ceramics, bone and shell. Insects were observed and included to illustrate pedogenic and decomposing activities. The numbers show the percentage of the sediment fraction represented by each type of microartefact. Note the elevated content, particularly for bone and shell. Where content represented less than 1% but it was observed in the sample, the word ‘traces’ is used. Stratum 1D was not included because it did not contain any microartefact. For Unit 3, Stratum B was not included because it might have had late (historic) influence. The microartefact analysis focused on Middle and East samples from Stratum C, giving a differential distribution of materials in the Unit. The geoarchaeological profile of Unit 1 (Figure 10.2) shows clear anthropogenic influence over all strata overlying stratum D, which is the natural soil before occupation. The combination of macro and microscopic results from Stratum C suggests that the natural forest surface was burnt before habitation and the accumulation of shell midden occurred later.

Unit 4 shows a complex profile, also entirely anthropogenic (Figure 10.2, Table 10.1). Although the pre-occupation surface was not reached during the geoarchaeological sampling, the analysis of the stratigraphy documented in previous excavations (Ayes and Davila 1993; Rivera-Collazo 2011a) suggests that the substrate is similar to Unit 1 Stratum D. Starting from the bottom, the sampled stratigraphic sequence over the natural clay-over-bedrock (Stratum D in Unit 1) consists of: 1) an artificial shell layer with some bone and charcoal, but almost no fine grains (Strata J and I); 2) an artificial layer of fine-grained sediments with no macroartefacts but very high content of microartefacts, particularly charcoal and bone (masticated and possibly digested) and presence of insect remains, interpreted as a habitation surface (Stratum H); and 3) shell midden deposit or accumulated food refuse (Strata G and F).

Unit 3 presents a very different profile. The entire stratigraphy is black. The diversity of the microartefact content in very high percentages suggests

very dense and constant human activity over the surface. The organic matter and phosphate content are very high, and the magnetic susceptibility signature indicates that while fire might not have directly affected the surface, artificial enhancement did occur, particularly in the lower strata. These geoarchaeological characteristics suggest that the unit is an anthropogenic soil, similar to the dark earths that form in permanent settlements which are characterized by long-term habitation and the local disposal of domestic refuse (Arroyo-Kalin 2009; Arroyo-Kalin et al. 2009; Graham 2006; Rebellato et al. 2009; Schaen 2010). The density of microartefacts suggests constant, intense human activity, including the purposeful removal of large refuse, which would have been transported and discarded in the middens. A radiocarbon date retrieved from this unit dates to 2.1k cal BP (2295–2270; 2155–1998 cal BP; 2σ , 95.4% probability, Beta-294435). Other dates from the site range from 3.7k to 4.2k cal BP. The archaeological assemblage indicates cultural continuity throughout the site. Black strata, very similar to Unit 3, were also identified in between all mounds, and in discrete areas on the Mounds.

The presence of dark earths produced by intensive, long-term settlement in an Archaic context is very important given that these groups are traditionally interpreted as mobile. The presence of dark earth within the site, adjacent to areas with midden and habitation surfaces, suggest that horticultural gardening and activities with high organic refuse accumulation as byproduct might also have occurred on site.

Salto Arriba

The graphs in Figure 10.3 show grain size percentage divided, from left to right (lighter to darker colors) in pebble, sand, silt and clay content. Organic matter is also presented as the percentage of content per weight of sample. Phosphates are shown in a scale of 0–3 (see text for explanation). Magnetic susceptibility shows low frequency (χ_{lf}) and maximum potential (χ_{max}) together within one graph, and the fractional conversion (χ_{conv}) in the last graph, illustrating the relationship between χ_{lf} and χ_{max} . The results from Salto Arriba and Angostura are in the same scale to facilitate comparison between records. The results of the microartefact analysis are shown in Table 10.2. The column to the left marks the unit and the level analyzed, along with the sample ID (BSAU#) to correlate with the results in Figure 10.3. Observed microartefacts include charcoal (burnt seed/fruit and wood), microlithics and ceramics. Bone and shell are included in the table, but were not observed in the analysis. The columns are included to maintain consistency with Table 10.1. Insects were observed and included to illustrate pedogenic and decomposing activities. The numbers show the percentage of the sediment fraction represented by each type of microartefact. Where content represented less than 1% but it was observed in the sample, the word ‘traces’ is used. Note the drastically lower microartefact content when compared to

the results in Table 10.1. Unit 2 contains almost no microartefact aside of charcoal. Unit 13 contains more significant percentages, particularly in the samples associated with the ballcourt (batey) floor (16–17) and immediately above and below, illustrating patterns of human use of this surface. Even in this context, the sediment matrix is mostly alluvial and human influence is very low. The most striking aspects of the geoarchaeological analysis of the Salto Arriba samples are the very low microartefact content and phosphate readings. In contrast to Angostura, where dense, constant activity altered the land surface, the sediments from Salto Arriba are mostly natural accumulation of alluvial sediments. Human activity, although important, was not a significant contributor to the parent material of the soils.

The sediments of Unit 13 were indeed affected by human activity, in particular burning over the ballcourt (batey) floor. High magnetic susceptibility and microartefact diversity (although in low percentages) indicate that humans did modify the ferromagnetic components of the natural strata and regularly conducted activities over the surfaces. The low abundance of microartefacts per volume of sediment, however, suggests that human occupation was not intense. Radiocarbon dates from this area place occupation between cal AD 1130 and 1360 (Rodríguez Ramos 2014: 30).

The sediments of Unit 2, on the other hand, seem almost natural in their composition, even the dark feature (samples 9–11). It would be difficult to differentiate the feature from a natural soil were it not for the presence of ceramics and other artefacts in the macroartefact assemblage, and the presence of burnt fruit/seeds and very few microartefacts in samples 9–11. However, the very low fractional conversion of the magnetic susceptibility is anomalous within this depositional environment. Even the modern, active soil has higher χ_{LF} readings than this dark feature, despite the fact that the parent material is identical. The charcoal content, in particular the higher presence of charred fruit/seed, the absence of phosphate reaction and the abnormally high organic matter content (for the location), combined with large broken pots and the identification of possible individual dump events in the stratigraphy reported by Rodríguez Ramos (pers. comm. 2015), suggests that the formation process of this deposit is anthropogenic.

It seems that even though not evident macroscopically, people used this particular location to discard uncharred organic refuse, such as rinds or other uncooked refuse. The presence of small fine-grain concretions in sample 10 suggests the surface was left exposed to bake under direct sunlight for some time – promoting the precipitation of calcium carbonate to cement individual fine grains – before additional dumping activities occurred. These additional activities attracted insects and other decomposers, and were later buried by flooding of the river and abandonment of this section of the site. Occupation did continue later in other areas, as indicated by the radiocarbon dates from Unit 13.

As suggested by Rodríguez Ramos, this dark feature seems to be a compost pit that could have been used to fertilize agricultural plots. Similar

composting practices still continue today in the region and are known as *aholla'o de mina*. Radiocarbon dating from the sediment feature date it between cal AD 935 and 1110 (Rodríguez Ramos 2014: 30). Additional microbotanical testing of the feature should be carried out to test what type of materials were being composted.

Aside from the low intensity of occupation for such a large multi-component site, another very interesting aspect of the sediment samples analyzed from Salto Arriba is the absence of shells and bones. A possible explanation is decomposition by soil acidity, but the sediments are only slightly acidic (see Figure 10.3) and there are absolutely no remains, not even partially decomposed, eroded or fractured microscopic bone remains. Another aspect is that bone decomposition by acid dissolution would be expected to enhance phosphate content, and the phosphate reaction in all samples is low or non-existent. It is possible that we are only looking at a marginal area of the site where animal protein was not consumed, but no refuse middens or areas with food refuse that include bones has been reported anywhere on the site (Rodríguez Ramos pers. comm. 2015). Even if food refuse was accumulated and discarded in the river to be flushed away by the running water, hunting and cleaning animals, disposing of their blood, cutting the sections to be consumed and eating them would produce microscopic refuse that would remain in the sediments, and would enhance the phosphates after dissolving with the soil acidity. It is possible that meat protein was processed elsewhere in the site, but the absence of any evidence for consumption of animals in the two examined areas is certainly puzzling.

Domesticating the island

In the Caribbean, particularly in the archipelago, the interpretation of landscapes and landforms has received little attention given that intense human impact on the landforms is seen as occurring only after the Spanish conquest, but assumed almost insignificant before then (see discussion in Rivera-Collazo 2015). However, human niche construction on the islands started with the earliest migrations, and possibly before, during the first exploratory expeditions. Recent paleoethnobotanical studies have revealed that people brought with them an assemblage of cultivars and domesticates, and continued producing them on the islands (Pagán Jiménez et al. 2015). Other studies also suggest early movement of animals, such as the *Isolobodon portoricensis* introduced to Puerto Rico by at least by 4.1k BP (Rivera-Collazo 2011b). Native practices of plant management included home gardens, arboriculture, cultivation of local wild species and agriculture through slash-and-burn, mound building and even terracing (Arroyo-Kalin 2012; Newsom 2008; Newsom and Wing 2004). Management of the landscape and artificial manipulation of the productivity of the land were part of the indigenous, pre-European traditions.

In this chapter, we have considered activities that could have modified the soils within two archaeological sites of different periods, and how these

modifications could have contributed to the enhancement of land productivity as part of the 'domestication' of the island. The results discussed earlier suggest that people during the Archaic Age impacted the land surface much more intensively than previously considered. The possibly unintentional creation of anthropogenic dark earth suggests that people were living on the site permanently and intensively, accumulating refuse and possibly maintaining house gardens on the site. In addition, the accumulation of sediment layers, where archaeological refuse is the dominant parent material, highlights anthropogenic impacts on the landscape, and the formation of anthropic soils of different characteristics, not only for agriculture.

On the other hand, the site of Salto Arriba illustrates that intensity of occupation during the Agro-Ceramic Age was much lower than during the Archaic Age, notwithstanding the evidence of widespread intentional land modification as suggested by the dimensions of the site and the architectural investment on the construction of several plazas and ballcourts. The presence of a compost pit very close to one of the habitation areas of the site suggests planned, long-term investment of time and effort to enhance land productivity. This traditional knowledge of land management seems to have continued to the present, in spite of the influence of European traditions since then.

Even if the natural soils of Salto Arriba do not compare to the nutrient depleted soils of Amazonia, the fact that compost was being produced calls for a more in-depth study of the chemical properties of such features to understand the particular necessities envisaged or problems faced by these communities for crop production. We have yet to produce data that respond to questions relating to soil fertility, nutrient availability and the particular plant species preferred by the diverse pre-Columbian cultural groups. Understanding the agricultural practices of the community living in Salto Arriba would require additional sampling of the wider landscape, but sadly, the site has been greatly impacted by the construction of a university campus, and what is left of this massive site is quite minimal. The analysis suggests that agricultural areas have distinctive geoarchaeological markers. However, the low content of archaeological artefacts would mean that sampling strategies that delimit sites by the presence or absence of ceramics or other archaeological remains would completely or partially miss these important areas of subsistence practices. Therefore, comprehensive studies must include a consideration of sites within the context of their contemporaneous landscapes.

The knowledge to manage, modify and 'domesticate' the islands is integral to the characterization of the *aquapelago*, or the human experience of islands within maritime culture and long-distance social networks of shared traditions. The development of more in-depth analyses of the geoarchaeological record in the Caribbean to better understand the range of land management techniques is important. These techniques help us understand social processes and webs of relationships that expanded throughout the

Caribbean Basin, and which are linked to the movement of traditional and local ecological knowledge as people moved to and from places.

Multiple analyses of archaeological assemblages have been suggesting that the scenarios of circum-Caribbean interaction are very complex (e.g. Hofman et al. 2014; Laffoon et al. 2014; Rodríguez Ramos et al. 2013), much more so than the manner in which main texts have conceptualized them (e.g. Rouse 1992). At a local scale, our landscape study shows that settlement patterns within Puerto Rico were also very complex, as were social interactions and subsistence practices. Detailed geoarchaeological analyses are necessary for the understanding of daily life in pre-Columbian studies. Geoarchaeology as a research method can give us tools to address social complexity, and to unravel the richness of indigenous traditions of land management and food procurement which transformed their Neotropical environments. The recovery of this indigenous knowledge can help us enhance our resilience at the local and regional scales.

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11 Isotopic challenges and categorical stumbling blocks in Caribbean archaeology

A cautionary tale from Puerto Rico

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Introduction

While stable isotope analysis of preserved human tissues holds considerable promise for the characterization of ancient human subsistence, certain questions remain beyond the technique's grasp. A variety of factors inherent to the Caribbean, and Puerto Rico in particular, can combine to make even relatively coarse determinations of subsistence economy (i.e. foraging versus farming) difficult to ascertain using stable isotope analysis alone. Isotopic data derived from individuals from the early (2700–680 cal BC) site of Maruca, Puerto Rico, that illustrate these difficulties are presented in this chapter. Yet even if isotopic studies have the necessary resolution to allow us to characterize subsistence economy, questions of significance remain. What is a forager as opposed to a farmer? Is this a distinction without a difference? Are these idealized “types” meaningful in any emic sense, or are they archaeological constructions that actually serve to constrain and distort research and, ultimately, our understanding of the region's ancient societies?

In this chapter, both the methodological and epistemological limitations involved in the isotopic search for Puerto Rico's early farmers are examined. Ultimately, we conclude that while we can describe subsistence composition using isotopic means, we cannot characterize, in the sense of placing in existing categories, subsistence strategy, and that simple description may, in some ways, be superior to placing past societies into preconceived typologies.

Isotopic basics

The characterization of human paleodiet through isotope analysis is predicated on known variation in the carbon ($\delta^{13}\text{C}$) and nitrogen ($\delta^{15}\text{N}$) isotope signatures of broad classes of plant and animal foodstuffs. Nearly forty years of archaeological applications have validated this approach to paleodietary reconstruction, and recent innovations in, for example, mixture modeling, hold considerable promise for the probabilistic and uncertainty-integrated quantification of dietary inputs on an individual-by-individual basis.

In order to arrive at a paleodietary estimation of an ancient individual's subsistence basis, one compares the carbon and nitrogen isotope values measured in extracted and purified human bone collagen and hydroxyapatite with the isotope signatures of the edible portion of a range of possible foodstuffs (the "foodweb"). One can determine the relative contribution of each food class to an analyzed consumer's diet assuming that: 1) the biomolecules of interest are sufficiently well-preserved, 2) the reconstructed foodweb represents the actual range of foods consumed by the individual under analysis, 3) there exist significant differences in the isotopic signatures of the different classes of food within the foodweb, and 4) that fractionation (offsets in isotope values) between the consumed foods and the consumer's tissues is accurately understood. Given space limitations, readers are encouraged to consult one of the several reviews of this technique for further details on its methods and assumptions (Ambrose 1993; Lee-Thorp 2008; Pestle 2010).

Application of the technique to regions and time periods meeting the criteria provided earlier has produced remarkable results concerning, for example, the timing of introduction of isotopically distinct domesticates, and thus farming. In the Caribbean, however, not all of the enumerated assumptions can be met, and as such, determinations of subsistence economy can be difficult to make.

Caribbean challenges

The Caribbean climate and isoscape present at least two decided challenges to isotopic estimations of paleodiet. Combined, these lessen the likelihood of definitively identifying early farmers/farming by isotopic means alone. To begin with, the biomolecules necessary for stable isotope analysis are unlikely to survive on archaeological timescales in tropical/neotropical climatic regimes. As with most organic materials, collagen undergoes rapid degradation in high temperature and high moisture conditions. Using a large ($n=298$) corpus of radiometrically dated bone samples from Puerto Rican archaeological sites, we observed that collagen content decreases very rapidly, and that it is unlikely that samples older than cal AD 300–400 would be sufficiently well preserved for isotopic analysis, particularly in open-air locations (Pestle and Colvard 2012), although semi-sheltered sites may have conditions more conducive to long-term collagen survival (see Chinique de Armas et al. 2015). This finding mirrors the conclusions of researchers working with other organic biomolecules, for example DNA, from the Caribbean tropics (Schroeder et al. 2015). Similar concerns about the survival of diagenetically unaltered hydroxyapatite (bone's principal mineral) also exist given the high water content of most Caribbean burial environments. Considering the timing of the arrival of the insular Caribbean's earliest inhabitants (farmers or not), it seems unlikely that anything other than tooth enamel (see later) would survive sufficiently unaltered over

Table 11.1 $\delta^{13}\text{C}$ values of wild/endemic and introduced/
domesticated plant foodstuffs from Puerto Rico

Grouping	<i>n</i>	$\delta^{13}\text{C}$ (‰)
Wild C_3 .	59	-25.5 ± 1.9
Domesticated C_3 .	53	-25.4 ± 1.5
Wild C_4 .	20	-10.1 ± 1.3
Domesticated C_4 .	8	-11.3 ± 0.8

deep archaeological time scales, making the characterization of population-level subsistence strategy quite difficult.

Furthermore, unlike some of the classic isotopic studies of significant changes in subsistence economy (e.g. the timing of the introduction of maize agriculture in the Eastern Woodlands [Bender et al. 1981; van der Merwe and Vogel 1978]), the isoscape of plant and animal foodstuffs in ancient Puerto Rico is so complex as to make the identification of precocious agriculture extremely difficult. Indeed, plants of all three (isotopically distinct) photosynthetic pathways (C_3 , C_4 , and CAM) existed in Puerto Rico at the time of human arrival. Furthermore, as seen in Table 11.1, the carbon isotope values of wild/endemic and introduced/domesticated plant foodstuffs in Puerto Rico overlap entirely. Thus, the notion of measuring a diachronic sequence of human hydroxyapatite carbon isotope values (most typically employed for the estimation of carbohydrate intake) for a change brought about by the introduction of an isotopically distinct cultigen would not be a feasible strategy for identifying early agriculture in Puerto Rico. Indeed, some of the likely early managed or domesticated plants had their wild progenitors on the island (e.g. *Zamia portoricensis*) or have isotopic values identical to endemic plant species (e.g. *Manihot esculenta* and the island's many C_3 wild plants or *Zea mays* and the island's C_4 /CAM plant species). Sufficient isotopic differences do not exist between available foodstuffs, and thus isotopic analysis, by itself, is incapable of differentiating between foragers eating wild plant foodstuffs and farmers eating domesticated plants. For this reason, isotopic analysis may have greater utility when paired with other individual-level dietary proxy analysis, such as starch grains from dental calculus (Chinique de Armas et al. 2015).

Therefore, despite significant promise, isotopic determination of subsistence strategies of, in particular, the earliest inhabitants of Puerto Rico may yield only very contingent conclusions. This fact is illustrated later with new isotopic data from Archaic-age individuals from the site of Maruca.

Early Puerto Rican data points

The occupation of Maruca, located in the southern Puerto Rican municipality of Ponce (Figure 11.1), has been radiocarbon dated to between 2700 and

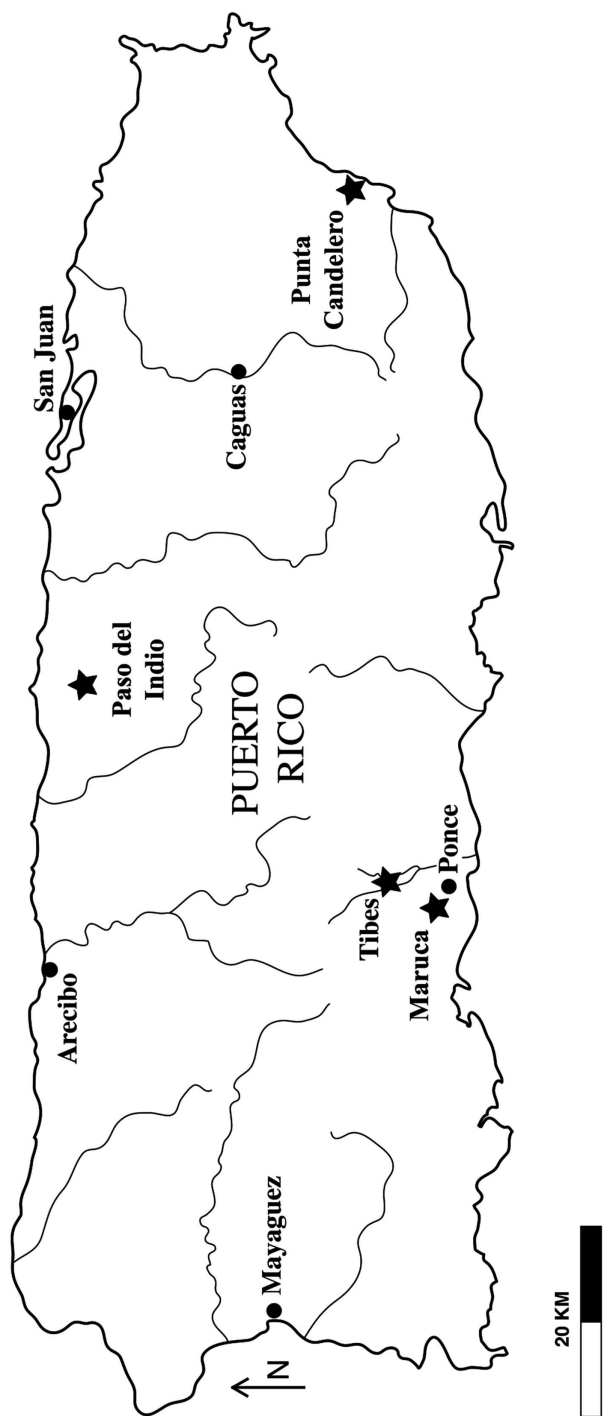


Figure 11.1. Map of Puerto Rico with locations mentioned in text noted. (Produced by authors).

Table 11.2 Archaeological, chemical, elemental, and isotopic data for Maruca bone and tooth samples

Individual	Bone				Enamel					
	Bone sample?	Tooth sample?	Collagen yield (wt%)	wt% C	wt% N	Atomic C.N	$\delta^{13}\text{C}_{ap}$ (‰)	$\delta^{13}\text{N}_{ap}$ (‰)	$\delta^{13}\text{C}_{ap}$ (‰)	$\delta^{13}\text{C}_{ap}$ (‰) raw corrected
2B	Y	Y	1.3	30.2	10.2	3.4	-18.3	8.8	-8.8	-
4	Y	Y	0.5	0.7	-	-	-	-	-12.1	-14.4
9	Y	Y	0.3	1.4	-	-	-	-	-9.6	-11.9
10	Y	N	0.3	1.4	-	-	-	-	n/a	n/a

680 cal BC, making it one of the earliest sites of human habitation on the island (Rodríguez López 1997, 1999, 2004; Rodríguez Ramos 2007). Excavations in the mid-1990s identified vestiges of structures, lithic and shell tool workshops, and a total of eleven human burials, which represent the largest assemblage of skeletal materials belonging to the Archaic Period of Puerto Rico (Crespo Torres 2004). Our efforts have located remains from four of these individuals, from whom we collected bone and/or tooth samples as was possible (Table 11.2).

Collagen extraction was performed using a modified version of the Longin (1971) method whereas pre-treatment of bone and enamel hydroxyapatite largely followed Lee-Thorp et al. (1989), with the addition of a vacuum treatment (Krueger 1991). The extracted materials (when sufficiently preserved, see later and Table 11.2) were analyzed by elemental analysis- and gas bench-isotope ratio mass spectrometry (EA-IRMS and GB-IRMS) at the University of Illinois, Urbana Champaign and the Stable Isotope Laboratory at the University of Miami's Rosenstiel School of Marine and Atmospheric Science. These processes and methods generate data on the state of collagen preservation (collagen weight yield, carbon and nitrogen elemental yields, and atomic carbon to nitrogen ratios) as well as isotopic data offering insights into dietary protein (from the stable isotope values of collagen carbon and nitrogen, $\delta^{13}\text{C}_{\text{co}}$ and $\delta^{15}\text{N}_{\text{co}}$) and energy/carbohydrates (based on stable isotope ratios of carbon in hydroxyapatite, or $\delta^{13}\text{C}_{\text{ap}}$).

As predicted, the combination of these samples' ages and the harsh conditions of preservation at this locality meant that of the four bone samples analyzed, only one, individual 2B, had sufficient bone collagen (1.3 wt%) to merit proceeding with isotopic analysis (for either bone collagen or hydroxyapatite). The other three samples' collagen content (averaging 0.4 wt%) fell below the recommended cutoff value of 1.0 wt% (Ambrose 1990; van Klinken 1999). The one sufficiently well-preserved sample, while having a low collagen yield, nonetheless had elemental characteristics consistent with unaltered collagen, most importantly having an atomic C:N ratio of 3.4, within the typically cited acceptable range of 2.9–3.6 (Ambrose 1990; van Klinken 1999). This is consistent with our previous study of Ceramic Age Puerto Rican samples, which found that while collagen content decreased rapidly in Puerto Rican burial environments, what collagen remained was structurally and chemically sound (Pestle and Colvard 2012).

In addition, the analysis of dental enamel yielded results for two of the three sampled individuals (4 and 9). In this case, the limiting factor was not preservation, given that enamel is generally impervious to diagenetic alteration (Koch et al. 1997; Lee-Thorp and Sponheimer 2003; Trueman et al. 2008), but rather that the sampled teeth of these individuals contained very little enamel due to extreme dental wear.

Isotopic data for the Maruca individuals are presented in Table 11.2. Unfortunately, while we possess ample comparative data for the Maruca bone data, no such comparative dataset exists for dental enamel from later

Puerto Rican individuals, and the $\delta^{13}\text{C}_{\text{ap}}$ values of bone and enamel hydroxyapatite may not be directly comparable (in terms of age of tissue formation and/or different food-tissue isotope offsets). As such, we present both uncorrected and corrected enamel $\delta^{13}\text{C}_{\text{ap}}$ values (applying a correction that should make the data comparable) for the teeth in our later discussion (Warinner and Tuross 2009).

Comparing the solitary Maruca bone data point (individual 2B) with a corpus of 188 previously published (Pestle 2010) Puerto Rican Ceramic Age individuals (Figure 11.2), it is evident that in terms of dietary protein ($\delta^{15}\text{N}_{\text{co}}$) and dietary energy/carbohydrates ($\delta^{13}\text{C}_{\text{ap}}$), the Maruca individual 2B's diet was indistinguishable from that of the island's later (cal AD 400–1400) populations. This is not to suggest that the diet of these temporally disparate peoples was identical, but rather that the isotopic balance of the mixture of foods (proteinaceous and energetic) they consumed, over the lifetime of the bone tissue analyzed, was equivalent.

Comparing the dental enamel $\delta^{13}\text{C}_{\text{ap}}$ values (uncorrected and corrected) with the bone $\delta^{13}\text{C}_{\text{ap}}$ values of the same 188 Ceramic Age individuals, as seen in Figure 11.3, a slightly different picture emerges. While the uncorrected $\delta^{13}\text{C}_{\text{ap}}$ values of the Maruca dental enamel overlap with the lower end of the Ceramic Age individuals' $\delta^{13}\text{C}_{\text{ap}}$ range (-12.4‰ to -4.7‰), they are notably

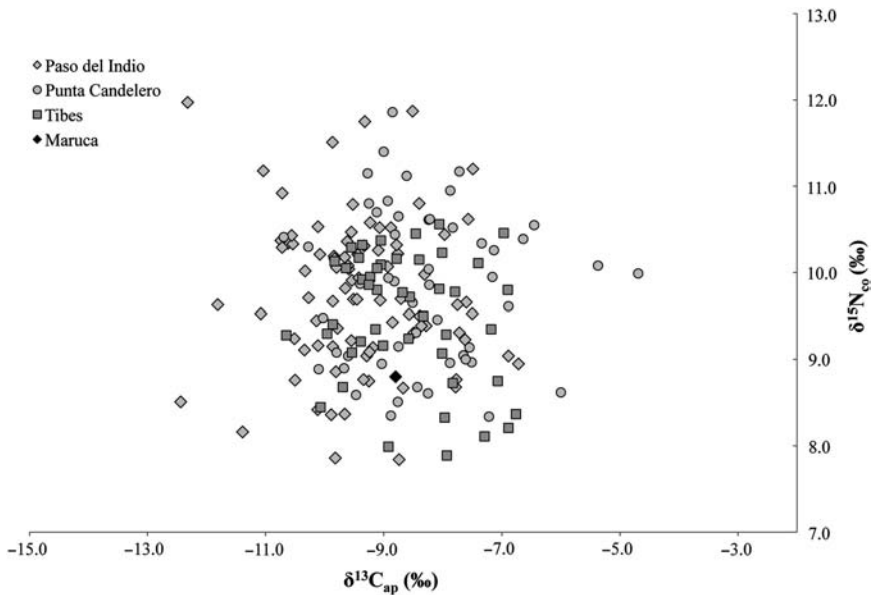


Figure 11.2 Scatterplot comparing $\delta^{13}\text{C}_{\text{ap}}$ and $\delta^{15}\text{N}_{\text{co}}$ values of previously published Ceramic Age individuals from Puerto Rico (Pestle 2010) with Maruca individual 2B. (Produced by authors).

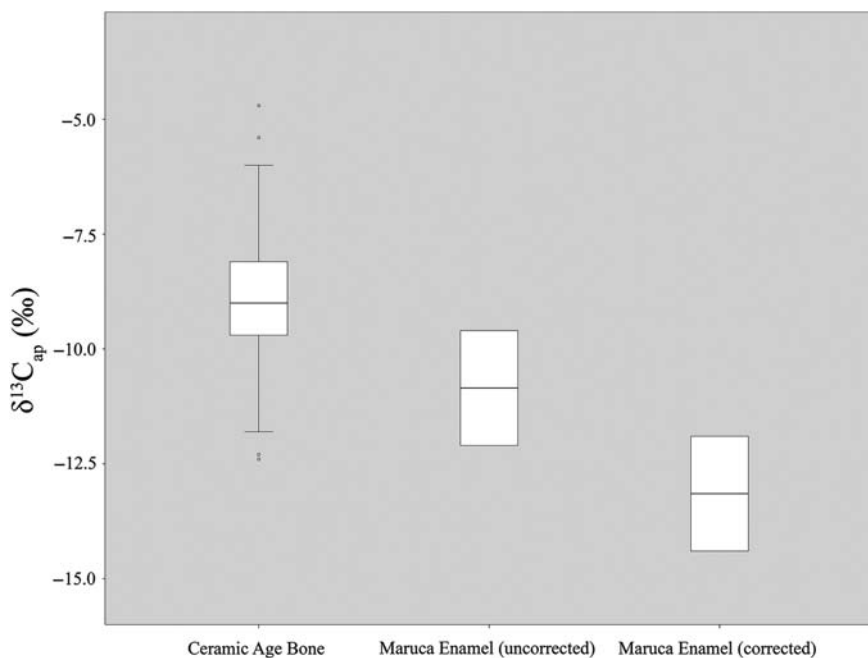


Figure 11.3 Boxplot comparing $\delta^{13}C_{ap}$ values of previously published Ceramic Age Puerto Rican bone samples (Pestle 2010) with corrected and uncorrected $\delta^{13}C_{ap}$ values of Maruca dental enamel. (Produced by authors).

lower, and the corrected values fall entirely below the comparative sample's range of values. This difference could either be a consequence of differences in the age of formation represented by teeth versus bone (in which case, it simply shows that childhood diet at Maruca was different from adult diet in later periods), the incomparability of different sample tissues, or it could provide evidence of a heavier reliance on C_3 plants (which have lower $\delta^{13}C$ values) on the part of the Maruca individuals. We have previously argued that the somewhat highly elevated $\delta^{13}C_{ap}$ values of the Puerto Rican Ceramic Age individuals is a result of the consumption of C_4 cultigens, such as maize (Pestle 2010), and thus the lower values in the Maruca individuals analyzed would appear as testimony to a different dietary regime, featuring more C_3 plants.

Interestingly, Pagán Jiménez (2011, 2013; Pagán Jiménez et al. 2005) has documented a wide spectrum of plants, both cultivated and wild, being used in Maruca and other early sites. These include plants such as maize (C_4), beans, sweet potatoes, manioc, arrowhead, arrowroot, achira, zamia, and wild yam (all C_3), among others. Thus, while the isotopic information is not

conclusive, in the case of Maruca, as regards dietary dependency on cultivated versus wild plants, the similarity of the isotope signatures when compared to the later occupants of the island might denote a degree of consistency or continuity in subsistence through time in the island.

What should be obvious from this discussion is that due, in particular, to the complexity of the local isoscape, it is impossible to differentiate definitively between habitual foragers and farmers. The sole bone data point that we possess suggests dietary similarities between the Maruca individual and later, presumably agricultural, populations, whereas the dental enamel data indicates substantial dietary difference. Unfortunately, both isotopically identical and isotopically disparate signatures could result from disparate systems of subsistence, as both wild and domesticated species of plants having chemical characteristics capable of generating the observed Maruca values exist in Puerto Rico. Indeed, given the isotopic similarities of wild and domesticated plant species in this environment, it could be said that both early and later human populations were farmers or foragers, according to the whim or wish of the researcher interpreting the results. Isotope analysis would thus seem poorly suited to answering the questions of when, or by whom, agriculture was first practiced in Puerto Rico. While we can characterize dietary makeup by isotope analysis, we cannot speak to how those foods were procured/produced. Thus, foragers and farmers in ancient Puerto Rico would appear chemically indistinct, regardless of when farming, as a practice, was introduced. And yet, in light of changing perspectives, we ought to realize that identifying the means of subsistence procurement may not be a goal worth pursuing too doggedly, and that characterizing dietary makeup may be a useful goal in and of itself.

Either/or vs. and

The works of Smith (2001, 2007) and Terrell et al. (2003), among others, advise us of the folly of a dualistic perspective as regards subsistence economy and the perils of typology. While most modern, and indeed many ancient, human societies fall neatly into either the category of food foragers or food producers, the mid-ground between the two extremes was (and is) populated by a myriad of people whose subsistence was based on a combination of both. At best, the differentiation of foragers vis-à-vis farmers is a distinction without a difference and, at worst, it may actually be harmful to our attempts to enhance our knowledge of the lifeways of the ancient societies of the Caribbean (see Rodríguez Ramos 2015).

The archaeological reification of “pure” expressions of subsistence economy and our obeisance to types is harmful for at least three reasons. First, the basic human need, as far as subsistence is concerned, is to obtain necessary macro- and micronutrients through culturally appropriate means. As such, the labels imposed by archaeologists are of little import to the societies striving, by any available combination of subsistence means, to

meet that goal. Hence the labels applied by archaeologists would be expected to have little, if any, emic significance. Moreover, as Smith (2001) amply discusses, even the labels assigned to these societies in the middle (incipient agriculturalists, complex hunter-gatherers) are teleological, and assume that if said societies, if left alone for long enough, would have eventually obtained their intended and inevitable goal of full agricultural reliance.

Second, the persistence of a dualistic perspective results in a form of forced categorization that simultaneously over-emphasizes oftentimes subtle variations in subsistence economy. Is a society that obtains 49% of its daily calories from domesticated sources categorically different from one that subsists on 51% domesticates? Is the former a food foraging society and the latter a food producer? Equally, does the possession of one of a number of supposedly diagnostic traits (cultivation, management, tending, horticulture, house gardens, etc.) catapult a society from foraging to farming? This practice falsely homogenizes societies possessing of very different combinations of subsistence strategies, but also can split apart societies that differ in only very minor ways.

Third, and most importantly, a reliance on a dualistic classificatory system leads, in a broad sense, to a framing of research strategies and questions that will tend to misrepresent past societies and overlook more important avenues of research. The problem is not just that the labels we use are inaccurate or inapt, but rather that the persistence of dualistic typologies actually hinders productive research and limits understanding.

In various fields, the use of, in particular, dualistic typologies as interpretive frames has been problematized, if not invalidated. From communications studies we find the realization that such typologies:

[s]hould be recognized as “analytical schemes” or “heuristic devices” whose value lies in their usefulness ... Viewed critically, typologies are just any category, often unsystematically and haphazardly developed, and user-defined. They are arbitrary, implying only a model character, and they may lead to stereotyping.

(Herdin 2012: 604)

In finance as well, we find skepticism as to the effectiveness of using typologies to inform action, as, “they can come to narrow our view of reality. Typologies may also be perceived to be an end in themselves rather than a means to an end” (Angwin 2012: 65). Finally, much closer to home, Rice (1982: 48) reminds us of the following in discussing ceramic typologies:

Because classifications organize and structure data, they inevitably also organize and structure the formulation of research problems. However, classifications are only tools; they are a means to an end, not ends themselves. Thus it is necessary to ask continually if the goals and procedures of ceramic research are existing in optimal relationships, or if

classificatory systems, which are always conservative and resistant to innovation, may be impeding rather than enhancing ceramic research.

This allusion to ceramic analysis should call to mind the recent (and not so recent) critiques of the Rousean system (Curet 2003, 2004, 2005; Gutiérrez and Rodríguez 2009; Keegan 2001, 2010; Pestle et al. 2013; Rodríguez Ramos 2007; Rodríguez Ramos et al. 2010; Ulloa Hung 2005), in which the negative impacts of such typological blinders are made all too clear. Weighed down by these systems (Rousean or forager-farmer), we ask the wrong questions, organize our data incorrectly, and thus get the wrong answers. Indeed, as Smith (2001: 5–6) notes, in the case of subsistence economy, “it is easy enough to find evidence of the substantial extent to which the dualistic epistemology continues to obfuscate and hinder consideration of the conceptual and developmental territory that stretches between hunting–gathering and agriculture.”

Given the problematic nature of the categorical exercise, it would seem that moving beyond the assignation of labels, and the assumption that social or political correlates follow from these labels (Arnold et al. 2015), would be the wisest course of action. This is particularly true in light of the evidence that even the earliest inhabitants of the insular Caribbean likely employed a mixed subsistence strategy involving both foraging and agriculture/plant and animal management (Burney et al. 1994; Newsom 1993; Pagán Jiménez et al. 2005), demonstrating that, “there was never a pre-agricultural period in the islands” (Rodríguez Ramos 2015: 13). Indeed, in a manner akin to that demonstrated by Espenshade et al. (2014) in their Rouse-free (or at least Rouse-light) analysis of Puerto Rican ceramics, perhaps we should focus on describing, rather than classifying, ancient subsistence composition. This goal is, conveniently, obtainable by means of stable isotope analysis.

Final thoughts

As the analysis of samples from Maruca illustrates, the task of identifying dependency on cultivated products in order to characterize subsistence economy in ancient Puerto Rico by isotopic means may be a methodological bridge too far to cross at the moment. A more important question, however, is why the assignation of labels of subsistence means would be judged more important than a determination of subsistence content, especially if the means of food procurement cannot be judged by isotopic means. In this chapter, we have presented some discussion of the ways in which a dualistic perspective on subsistence economy is harmful to fruitful research, and, as a consequence, we suggest that the multi-proxy identification of foods consumed, rather than just their means of procurement, ought be the principle goal of isotopic research in the region. In that light, the data from Maruca offer some insights into the consumptive practices of some of Puerto Rico’s earliest inhabitants. On the one hand, bone data suggests a protein and

carbohydrate diet not dissimilar from later island inhabitants, whereas data from dental enamel suggests a heavier reliance on C_3 plants than is observed in later, Ceramic Age, populations. If directly comparable, this finding could be taken to indicate that the kinds of plants, if not their means of procurement, of Archaic peoples in Puerto Rico were different than those typically consumed by the island's later inhabitants, but then the bone data point suggests overall similarity. Clearly, more work needs to be done.

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12 Assessing dietary and subsistence transitions on prehistoric Aruba

Preliminary bioarchaeological evidence

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Introduction

Traditional models of Caribbean culture history generally postulate that the earliest prehistoric occupations of the region (Paleo-Indian or Archaic Age), beginning as early as ca. 7000 BP, were dominated solely by hunter-gatherer-fishers, and that farming was a later (Ceramic Age) introduction to the region by Saladoid migrants arriving from the Orinoco River Delta area of north-eastern South America beginning around 2500 BP (Rouse 1992). Much archaeological research over the last several decades has called into question the simplistic dichotomy between so-called Archaic (hunter-gatherer-fisher) and Ceramic Age (horticultural/agricultural) modes of subsistence (Keegan 2006; Pagán Jiménez 2011; Rodríguez Ramos 2010). Although there is as yet no consensus on these topics, multiple lines of evidence indicate that: 1) certain practices (often inappropriately) exclusively associated with farming communities (e.g., production and use of ceramics, translocation of plants and animals, widespread landscape alterations) occurred during the Archaic Age; 2) subsistence and dietary patterns and subsequent diachronic changes were highly variable in different parts of the insular Caribbean; and 3) hunting-gathering-fishing likely made important contributions to prehistoric Caribbean food-ways well into the Ceramic Age and beyond. Many questions concerning synchronic and diachronic variation in ancient Antillean food-ways in general and regarding dietary and subsistence transitions between Archaic Age and Ceramic Age populations in particular, remain unresolved (see also Pestle and Rodríguez Ramos, this volume). These lacunae are in part a reflection of the relative dearth of information about Archaic Age occupations of the Caribbean, with factors such as low population densities, high mobility patterns, poor preservation conditions, and highly variable research histories greatly reducing the quality and quantity of archaeological evidence required to address these questions.

For this study, we applied a combined bioarchaeological approach, utilizing dental anthropological and stable isotopic analyses to assess long-term changes in subsistence patterns on prehistoric Aruba. We argue that human

dentitions are ideal foci for intensified research owing to their vast potential as archives for a wide variety of human behavioral processes and to their generally good states of preservation relative to many other types of archaeological materials from the prehistoric Caribbean. Comparisons of patterns of dental pathologies and isotope results between individuals from the Archaic Age sites of Canashito and Malmok and the Ceramic Age (Dabajuroid) sites of Santa Cruz, Savaneta, and Tanki Flip do not reveal distinct differences between the two groups.¹

Background

The Archaic or Pre-Ceramic occupation of Aruba persisted well into the first millennium AD, which is relatively late in comparison to other parts of the insular Caribbean. Archaic lifestyle on the island is traditionally characterized as based on a hunter-gatherer-fisher food economy, with a major focus on marine resource acquisition, a lack of ceramics and horticulture/agriculture, and social organization in small bands (National Archaeological Museum Aruba 2010). Archaic sites tend to be identified based mainly on the lack of ceramics, with archaeological remains recovered at Archaic sites on Aruba predominantly comprising shell food remains. Two Archaic sites with human burials are incorporated into this study.

Canashito is a limestone rock-shelter in central Aruba, close to the large Ceramic Age/contact period settlement of Santa Cruz. Shell food remains were recovered from the slope leading to the entrance of the rock-shelter, and five human burials were uncovered under the abri. Radiocarbon dating of one of the skeletons revealed a date of 1960 ± 65 BP, or cal. AD 83–394 (Versteeg et al. 1990; Wagenaar Hummelinck 1959). Malmok is a burial site on the north-western tip of Aruba, in an area that is ideally positioned to exploit a variety of ecological zones. Investigations at the site show that the cemetery was used between the 6th and 9th centuries AD. An oval-shaped shell midden, consisting of a very shallow deposit of food remains, was found just north of the burial area, and was considered not to have been the result of long-term exploitation of the area or permanent habitation. Radiocarbon dating of shell material from the midden indicated that it pre-dates the burials by at least two centuries. Over 60 burials have been identified at the site, although not all individuals have been excavated (Versteeg 1991, 1993; Versteeg et al. 1990).

The Ceramic Age occupation of Aruba is traditionally contrasted with the Archaic occupation, and is thought to represent a new wave of migration from the mainland to the island, bringing with it ceramics, large settlements, and an agricultural food economy (National Archaeological Museum Aruba 2010). The three Ceramic Age sites incorporated in this study, Santa Cruz, Savaneta, and Tanki Flip, comprised large habitation sites with a main period of use during AD 950–1250, although they are thought to have been inhabited up to the arrival of the Spaniards in the early 16th century (Bartone and

Versteeg 1995; National Archaeological Museum Aruba 2010). Santa Cruz is located approximately halfway between the windward and leeward coasts of Aruba, and is situated near the confluence of two guts (rooien) on arable land, making this area particularly attractive for agriculture (Versteeg 2001). Human skeletal remains were recovered in the area during excavations by Boerstra in 1971 and by Versteeg in 1991–1992. Excavations by Leiden University and the Archaeological Museum Aruba in 1991–1992, under the direction of Aad Versteeg, uncovered 31 burials, many containing the remains of multiple individuals (Boerstra 1974, 1982; Versteeg 1997, 2001). Savaneta is situated on a limestone substrate on the south-western coast of Aruba, in the middle of an area with some of the best land for agriculture in the south of Aruba (Versteeg 2001; Versteeg and Rostain 1997; Versteeg and Ruiz 1995). Tanki Flip, located at 3 km from the coast in north-western Aruba, is situated on moisture-retaining diorite subsoil, close to a number of guts, making it well suited to agriculture in the predominantly dry Aruban environment (Versteeg 2001; Versteeg and Rostain 1997). Excavations in 1994–1995 revealed 13 oval and circular house structures. Seven burials containing the remains of 15 individuals were uncovered in 1994–1995. Previously, a large number of human skeletons had been uncovered at the three sites by Egbert Boerstra (Boerstra 1976; Versteeg and Rostain 1997). Based on the traditional understanding of food-ways during the Archaic and Ceramic Age occupations of Aruba, it is expected that the dental and isotopic analyses in this study will reflect differences in dietary practices between the Archaic and the Ceramic Age groups.

However, in a recent study of starch grains trapped in human dental calculus from three Aruban Archaic individuals and one Ceramic Age individual,² tuberous root plants were identified, including marunguey (*Zamia* sp.), sweet potato (*Ipomoea batatas*), cocoyam (*Xanthosoma* sp., *Xanthosoma* cf. *sagittifolium*), and manioc (*Manihot esculenta*), indicating that starchy plant crops comprised a part of the diet in both periods. Furthermore, in three of the four sampled individuals, maize starch (*Zea mays*, cf. *Zea mays*) was identified. Some of the uncovered starch grains displayed alterations in morphometric characteristics and patterns of damage consistent with pressure and heat treatment, i.e., from food preparation (Mickleburgh and Pagán Jiménez 2012). Although starch grain evidence from dental calculus does not provide insight into the size of the plant food contribution to the diet, these results do indicate that next to the collection of wild plant foods, starchy food crops typically considered to have formed the basis of the agricultural food economy in Ceramic Age settlements were also contributing to Archaic diets. Last, the presence of large shell middens and the numerous remains of marine fauna at all three of the Ceramic Age sites included in the samples is testimony to the fact that marine food continued to comprise an important part of the diet at these habitation sites (Grouard 1995, 1997; Versteeg and Rostain 1997). In order to investigate potential dietary differences and assess long-term dietary transitions between the two



Figure 12.1 Map of the Caribbean, with inset of Aruba showing sites. (Produced by H. Mickleburgh).

groups, we compared rates of dental pathology and dental wear, enamel carbon isotopes, and dentine collagen carbon and nitrogen isotopes between Archaic and Ceramic Age individuals from five sites on Aruba (Figure 12.1).

Methods and material

The sample available for dental analysis comprises 23 individuals, from 2 Archaic sites (Canashito and Malmok) and 3 Ceramic sites (Santa Cruz, Savaneta, and Tanki Flip). Dentitions were examined macroscopically and microscopically for the presence of dental wear and pathology. Caries, AMTL, abscesses, and dental calculus were recorded per individual and per tooth/socket. Dental calculus was recorded following Brothwell (1981: 155). Dental wear was scored according to Smith's ordinal scale (Smith 1984). As a relatively large number of teeth were missing due to taphonomic and collection issues, to maximize sample size all observed teeth for each individual were scored. Intra-individual rates of molar wear, calculated with principal axis analysis, which avoids the effects of different age profiles between populations as it relies on the interval in which the adjacent molars erupt (approximately six years), can offer insights into abrasiveness of foods and food preparation techniques (Scott 1979; Sokal and Rohlf 1981; Watson et al. 2013). However, due to the small sample size in this study, comparisons

with principal axis analysis were not undertaken. To nonetheless gain insight into possible distinct differences between the groups, the difference in mean degree of wear of adjacent first and second molars was compared between the two groups.

Stable isotope methods comprised analyses of carbon isotope composition of dental enamel ($\delta^{13}\text{C}_{\text{en}}$), and carbon ($\delta^{13}\text{C}_{\text{co}}$) and nitrogen ($\delta^{15}\text{N}$) isotopes of dentine collagen. Sample processing and measurements were conducted at the VU University Amsterdam, and the details of analytical procedures and protocols are reported elsewhere (Laffoon 2012; Laffoon et al. 2013, 2016). Briefly, for enamel extraction the external crown surface was first cleaned, and 4–5 mg of core enamel was removed. Powdered enamel was pre-treated by sequential soaking in 2.5% bleach (NaOCl) and Ca-acetate buffered acetic acid (CH_3COOH), with thorough rinsing in ultrapure water (MilliQ- H_2O) following the protocol of Bocherens et al. (2011). Enamel $\delta^{13}\text{C}$ was measured on a DeltaPlus IRMS integrated with a GasBench auto-sampler, after dissolution of samples in 100% H_3PO_4 at 45°C for 24 hours. Measurements were normalized to the VPDB scale using an in-house carbonate standard (VICS) calibrated to a certified reference material (NBS-19). Instrument performance was monitored by an international standard (IAEA-CO1) with a reproducibility of $\pm 0.2\%$ (1σ).

For collagen sampling, the outer surface was first rinsed and mechanically cleaned, and a ~200–500mg fragment was removed. Collagen extraction followed a modified version of the protocol reported by Brown et al. (1988). Dentine fragments were demineralized in 0.6 M hydrochloric acid (HCl) at 4°C for 5–10 days (acid refreshed after 48 hours) and rinsed to neutral; soaked in a 0.125 M sodium hydroxide (NaOH) solution for 20 hours and rinsed again; gelatinized in 0.001 M HCl at 80°C for 24 hours; and then condensed and freeze-dried. Collagen $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ were measured on a ThermoQuest IRMS Delta XPplus with a Flash EA. Sample calibration was done with international standards (USGS-40 and USGS-41), and (IAEA-310A and IAEA-NO3) for $\delta^{13}\text{C}$ and $\delta^{15}\text{N}$ isotope analyses respectively. All isotope results are reported as delta (δ) values in per mille (‰) relative to VPDB for carbon and AIR for nitrogen.

Results of dental analysis

Comparison of the caries frequency of the two groups reveals a considerably higher rate in the Ceramic Age group (9.64%) than the Archaic Age group (0.00%). A chi-square test indicates the difference is statistically significant ($\chi^2(1, N=291) = 12.749, p=0.00$). The higher caries rate in the Ceramic Age group suggests that this group was consuming more cariogenic foods than the Archaic Age group. These may have included simple sugars, such as glucose, sucrose, and fructose, as well as other carbohydrates, including starches. Comparison of the overall caries frequency of 9.64% with a large number of populations with varying subsistence patterns worldwide, places

the Ceramic Age group most closely within the range of mixed diets (e.g., fisher-gardeners), or agricultural diets with relatively low caries frequencies (Pezo Lanfranco and Eggers 2012; Turner 1979). However, caries rates are affected by a large number of factors, including overall population health and susceptibility, specific food crops, and food preparation techniques, meaning that such global comparisons are of limited interpretative value. When compared to caries frequencies observed in other Ceramic Age Caribbean assemblages, the Aruban Ceramic Age group falls in the lower range (Mickleburgh 2013, 2014).

Comparisons of dental pathology rates between samples are known to be influenced by differing age profiles and differentially preserved/affected teeth. Furthermore, the different teeth and tooth surfaces in the dentition are differentially susceptible to carious lesions (Hillson 2001; Pezo Lanfranco and Eggers 2010, 2012; Wasterlain et al. 2009). To investigate such potential sources of variation, patterns of caries are usually assessed by sex, age group, tooth, and tooth surface; however, due to the small sample used in this study, this was not attempted. Nevertheless, based on known differential susceptibility of the different tooth elements and surfaces, some inferences can be made. The caries in the Ceramic Age group for the greater part only affected premolars and molars, with occlusal surfaces and cement-enamel junction affected to an equal degree. It is known that the molars and premolars are most susceptible to carious attack, even in diets with relatively low amounts of cariogenic foods. In populations with low carbohydrate intake, caries tend to predominantly affect the first molars, with second and third molars, premolars, and subsequently incisors and canines affected more frequently with greater carbohydrate consumption (Hillson 2001). The occlusal surfaces and cement-enamel junctions are likewise most susceptible to carious lesions, whereas the smooth surfaces of the crowns tend to be affected in highly cariogenic diets (Hillson 2001; Pezo Lanfranco and Eggers 2010, 2012; Wasterlain et al. 2009). As such, the pattern of caries location observed in the Ceramic Age group may indicate that the proportion of cariogenics in the diet was not extremely high. Combined with a relatively low overall caries frequency in comparison to other Ceramic Age communities in the region, this suggests a diet including, but not focused on, cariogenic plant foods, or alternatively a diet with highly cariogenic foods, but also containing a large amount of caries inhibiting foods (e.g., meat or fish).

On closer examination of the caries frequencies in both groups, it is apparent that the higher rate observed in the Ceramic Age group is mostly the result of high rates observed in individuals from the site of Santa Cruz, possibly indicating a distinct difference in dietary practices between Santa Cruz and the other two Ceramic Age sites (Table 12.1). Excluding Santa Cruz, the caries frequency of the Ceramic Age group is distinctly lower (1.85%), and falls well within the range most typically observed in subsistence types with low intake of cariogenics, i.e., a small proportion of sugars

Table 12.1 Caries rate per site

<i>Site</i>	<i>N</i>	<i>Frequency</i>
Canashito	47	0.00
Malmok	78	0.00
Santa Cruz	58	24.14
Savaneta	75	1.33
Tanki Flip	33	3.03

and starches, often combined with caries inhibiting foods and food preparation techniques (Pezo Lanfranco and Eggers 2010, 2012; Turner 1979).

Ante mortem tooth loss (AMTL) is slightly higher in the Ceramic Age group (6.02%) than the Archaic Age group (4.00%). The difference is not statistically significant ($\chi^2(1, N=291) = 3.39, p=0.07$), but may be related to the higher caries rates in the Ceramic Age group. Although dental wear can contribute to AMTL, it is more likely that caries was a major contributor, since while the rate of dental wear is lower in the Ceramic Age (see later), the frequency of both AMTL and caries increases. Periodontal disease, which was not scored here, may have contributed substantially to AMTL.

Additional comparative data from a dental study carried out by Jouke Tacoma on 24 other adult dentitions from the site of Malmok, was combined with the data from the current study to increase the sample size of the Archaic Age group (Versteeg et al. 1990). Tacoma scored AMTL, caries, alveolar abscesses, and congenital absence of the second premolars and third molars. In the 690 observed teeth, he found 3 carious teeth (2 premolars, 1 molar), belonging to 3 individuals. He observed 6 individuals with AMTL ($n=22$). The combined results of both studies reveal a similar picture to the results of the current study alone. Caries rates differ significantly between the Archaic (0.36%) and the Ceramic (9.64%) groups ($\chi^2(1, N=981) = 62.40, p=0.00$). AMTL rates are lower in the Archaic (3.31%) than in the Ceramic (6.02%) group; however, the difference is still not statistically significant ($\chi^2(1, N=981) = 2.79, p=0.10$).

An independent-samples t-test showed a significant difference in the mean dental wear scores for Archaic (mean=1.56, SD=0.81) and Ceramic samples (mean=0.50, SD=0.71); $t(32)=4.07, p=0.00$. This suggests that the rate of wear was considerably lower in the Ceramic Age group than in the Archaic Age group, indicating a reduction in the abrasivity of the overall diet, which could be related to the consumption of less abrasive foods, different food preparation techniques, or a combination of both factors. Based on the distinctly higher caries frequency found at Santa Cruz, the same comparison of the difference in mean degree of wear of adjacent first and second molars was made, excluding this site from the calculation. An independent-samples t-test again showed a significant difference in the scores for Archaic (mean=1.56, SD=0.81) and Ceramic means (mean=0.69, SD=0.75); $t(27)=2.96, p=0.00$,

although the rate of wear appears to be higher in the Ceramic Age group when Santa Cruz is excluded. The latter is consistent with the other Ceramic Age sites consuming a more marine or terrestrial animal oriented diet with only a very small horticultural/agricultural/ contribution.

Results of isotope analyses

The samples available for isotope analysis comprised nine individuals in total (Table 12.2). Although the sample size is limited, this preliminary data is used to explore possible differences in dietary patterning between Archaic and Ceramic Age groups and forms a basis for future sample selection and research. Dentine sampling focused on root tips, and not coronal dentine, where the tissue represents collagen formation in later childhood years. As such, they should contain little to no input from breastfeeding. Nonetheless, caution is warranted when comparing dentine versus bone collagen isotope results. In terms of collagen preservation, several samples produced insufficient collagen for isotopic analyses. Collagen yields for the remaining nine samples were variable, but the collagen quality control indicators (wt% C, wt% N, and atomic C:N ratios) fell within the acceptable ranges for archaeological skeletal materials (Ambrose 1990).

The isotope results display several notable patterns (Figures 12.2 and 12.3). The sole individual from the Archaic site of Canashito has significantly lower $\delta^{13}\text{C}_{\text{en}}$ (-11.0‰), $\delta^{13}\text{C}_{\text{co}}$ (-17.1‰) and $\delta^{15}\text{N}$ (11.1‰) values compared to all the other individuals indicating a much more terrestrial oriented diet. Previous strontium isotope ($^{87}\text{Sr}/^{86}\text{Sr}$) analysis of these same samples (Laffoon 2012) revealed that the individual from Canashito also possesses a high $^{87}\text{Sr}/^{86}\text{Sr}$ value that is inconsistent with childhood origins on Aruba based on comparisons with the estimated range of bioavailable $^{87}\text{Sr}/^{86}\text{Sr}$ variation on this island (Laffoon et al. 2012) and is thus a nonlocal. Based on comparison with macro-regional models of $^{87}\text{Sr}/^{86}\text{Sr}$ variation (Bataille et al. 2012), the nearest location consistent with such a $^{87}\text{Sr}/^{86}\text{Sr}$ value is the north-central coast of Venezuela. This different natal origin may

Table 12.2 Sampling information and stable isotope results

ID	Site	Context	element	$\delta^{13}\text{C}_{\text{en}}$	$\delta^{13}\text{C}_{\text{co}}$	$\delta^{15}\text{N}_{\text{co}}$
3	Canashito	Archaic	1.7	-11.05	-17.13	11.10
6	Malmok	Archaic	3.8	-4.63	—	—
10	Malmok	Archaic	2.5	-4.84	-10.30	14.58
13	Malmok	Archaic	4.4	-3.94	-9.57	14.79
490	Malmok	Archaic	2.4	-5.32	-11.14	15.46
200	Tanki Flip	Ceramic	1.5	-3.08	—	—
488	Tanki Flip	Ceramic	1.3	-5.97	-7.01	15.99
237A	Savaneta	Ceramic	3.3	-2.59	—	—
1	Santa Cruz	Ceramic	1.7	-8.72	—	—

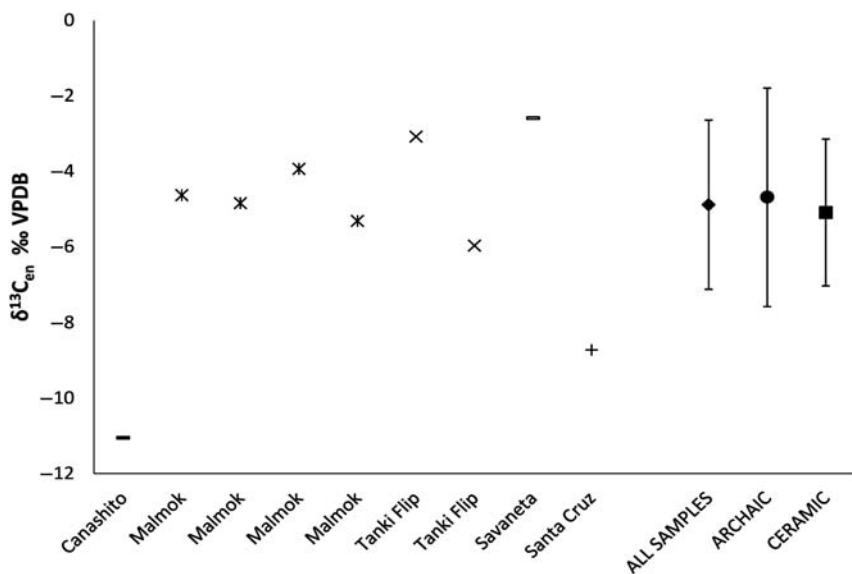


Figure 12.2 Chart of $\delta^{13}C_{en}$ results showing individual isotope values; and the mean ($\pm 1\sigma$) for All, Archaic, and Ceramic samples separately. (Produced by H. Mickleburgh).

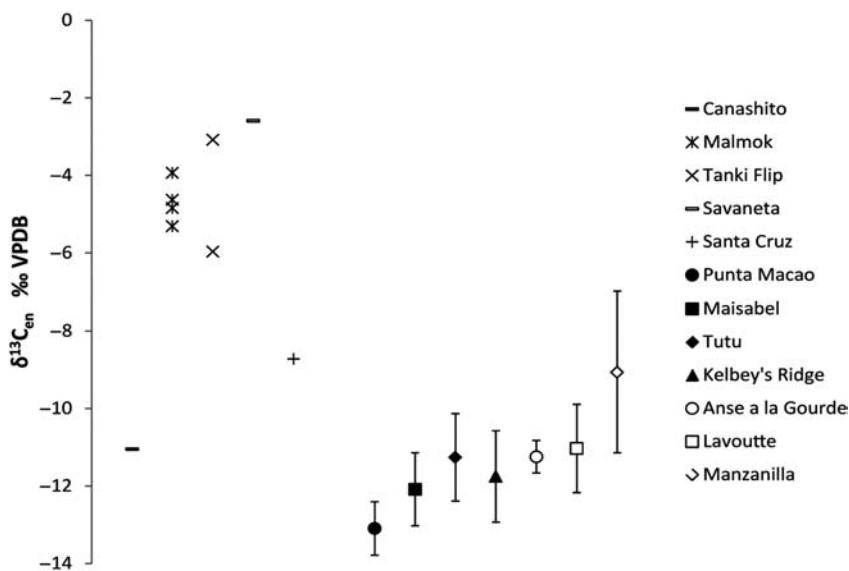


Figure 12.3 Chart of $\delta^{13}C_{co}$ and $\delta^{15}N$ results showing individual isotope values; and the mean ($\pm 1\sigma$) for All, Archaic, and Ceramic samples separately. (Produced by H. Mickleburgh).

also account for the observed difference in diet between this sample and the other Aruban samples in this study. As such, this individual sample will not be included in the statistical or comparative analyses.

All individuals from the Archaic Age site of Malmok have extremely elevated $\delta^{13}\text{C}_{\text{en}}$ (range: -5.3 to -3.9‰), and $\delta^{13}\text{C}_{\text{co}}$ (range: -11.1 to -9.6‰) and $\delta^{15}\text{N}$ (range: 14.6 to 15.5‰). The highly enriched collagen values indicate that marine resources were the dominant source of dietary protein for these individuals. The enriched $\delta^{13}\text{C}_{\text{en}}$ values could result either from large contributions of C_4/CAM plant³ resources to whole diet and/or that marine protein sources contributed substantially to dietary energy (i.e., high protein, low carbohydrate diets). For the Ceramic Age individuals, it is interesting to observe that their $\delta^{13}\text{C}_{\text{en}}$ values are also relatively elevated (ranging from -8.7 to -2.6‰) and overlap extensively with the Archaic Age individuals from Malmok. The Ceramic Age samples from Savaneta and Tanki Flip also have highly elevated $\delta^{13}\text{C}_{\text{en}}$ values that are very similar to Malmok. The single collagen sample from Tanki Flip has the highest $\delta^{13}\text{C}_{\text{co}}$ (-7.0‰) and $\delta^{15}\text{N}$ (16.0‰) values in the entire dataset indicating heavy reliance on marine resources for dietary protein. The single specimen from Santa Cruz possesses a $\delta^{13}\text{C}_{\text{en}}$ value (-8.7‰) that is intermediate between the two other extremes in the Aruban data set (i.e., between the much lower value for the Canashito nonlocal and the relatively higher values at the other three sites).

Overall, there are no statistically significant differences between the Archaic and Ceramic Age samples in mean $\delta^{13}\text{C}_{\text{en}}$ (Archaic = -4.7‰ ; Ceramic = -5.1‰). Although based on limited data, there is a substantial difference between the three Archaic Age individuals from Malmok (mean = -10.3‰) and the single Ceramic Age individual from Santa Cruz (-7.0‰) in collagen $\delta^{13}\text{C}_{\text{co}}$, but a much smaller difference in $\delta^{15}\text{N}$ (14.9‰ and 16.0‰ , respectively) (Table 12.3). Similar to some of the patterns in the dental data noted earlier, when comparing the isotope data by site, the Santa Cruz individual has a markedly lower $\delta^{13}\text{C}_{\text{en}}$ value compared to both the Archaic and the other two Ceramic Age sites. Excluding the Santa Cruz individuals from the comparison, there is little observable difference in $\delta^{13}\text{C}_{\text{en}}$ values between the Archaic Age (mean = -4.7‰) and Ceramic Age (mean = -3.9‰) samples. Thus based on the isotopic evidence there was no major diachronic shift in diet between the Archaic and Ceramic Age on Aruba per se, although there are apparent differences in diet between the (likely more recent) Santa Cruz individual and all of the other Aruban Archaic and Ceramic Age individuals combined (see discussion later).

The Aruban isotope results can also be compared to published tooth enamel (Laffoon et al. 2013), and bone apatite and collagen isotope data (Healy et al. 2013; Krigbaum et al. 2013; Laffoon and de Vos 2011; Norr 2002; Pestle 2010; Stokes 1998) from other precolonial populations of the Caribbean (Table 12.4). Carbon isotopes in enamel and bone bioapatite are not necessarily equivalent as they reflect different periods of mineralization; with enamel forming primarily in childhood, while bone not only continually

Table 12.3 Summary statistics of Aruban isotope results (excluding Canashito)

		$\delta^{13}C_{en}$	$\delta^{13}C_{co}$	$\delta^{15}N_{co}$
ALL*	MEAN	-4.9	-9.5	15.2
	MIN	-8.7	-11.1	14.6
	MAX	-2.6	-7.0	16.0
	SD	1.9	1.8	0.6
	N	8	4	4
ARCHAIC*	MEAN	-4.7	-10.3	14.9
	MIN	-5.3	-11.1	14.6
	MAX	-3.9	-9.6	15.5
	SD	0.6	0.8	0.5
	N	4	3	3
CERAMIC	MEAN	-5.1	-7.0	16.0
	MIN	-8.7	-7.0	16.0
	MAX	-2.6	-7.0	16.0
	SD	2.8	-7.0	16.0
	N	4	1	1

Table 12.4 Stable isotope data from several precolonial populations in the Antilles. Enamel $\delta^{13}C$ data are from Laffoon et al. 2013, 2016; Bone $\delta^{13}C$ and $\delta^{15}N$ data are from 1: Healy et al. 2013); 2: Krigbaum et al. 2013; 3: Laffoon et al. 2016; 4: Laffoon and de Vos 2011; 5: Stokes 1998; 6: Norr 2002

Island	Site	$\delta^{13}C_{en}$	$\delta^{13}C_{ap}$	$\delta^{13}C_{co}$	$\delta^{15}N$	source
		mean $\pm 1\sigma$	mean $\pm 1\sigma$	mean $\pm 1\sigma$	mean $\pm 1\sigma$	
Aruba	Multiple	-4.9 $\pm$ 1.9	n/a	-9.5 $\pm$ 1.8	15.2 $\pm$ 0.6	*
Trinidad	Manzanilla	-9.1 $\pm$ 2.1	-7.9 $\pm$ 0.4	-12.6 $\pm$ 0.9	10.0 $\pm$ 0.2	1
Carriacou	Grand Bay	n/a	-8.6 $\pm$ 0.6	-12.8 $\pm$ 0.9	11.1 $\pm$ 0.5	2
St. Lucia	Lavoutte	-11.0 $\pm$ 1.1	-9.1 $\pm$ 1.4	-16.0 $\pm$ 0.7	11.6 $\pm$ 0.5	3
Guadeloupe	Anse à la Gourde	-11.2 $\pm$ 0.4	-8.4 $\pm$ 1.3	-14.8 $\pm$ 0.8	10.9 $\pm$ 0.7	4,5
Saba	Kelbey's Ridge	-11.7 $\pm$ 1.2	-11.0 $\pm$ 1.3	-15.7 $\pm$ 0.6	10.8 $\pm$ 0.5	5
St. Thomas	Tutu	-11.3 $\pm$ 1.1	-10.5 $\pm$ 0.9	-15.5 $\pm$ 0.9	12.2 $\pm$ 0.9	6
Puerto Rico	Maisabel	-12.1 $\pm$ 0.9	-9.9 $\pm$ 0.9	-18.1 $\pm$ 1.0	9.7 $\pm$ 0.7	5
Domin. Rep.	Multiple	-13.1 $\pm$ 0.7	-12.1 $\pm$ 2.1	-17.7 $\pm$ 0.7	11.9 $\pm$ 0.4	5
Bahamas	Multiple	n/a	-10.8 $\pm$ 2.1	-13.4 $\pm$ 1.4	9.8 $\pm$ 1.0	5

remodels throughout life but is also more susceptible to post-mortem alteration. Therefore, caution is advised when comparing enamel and bone carbon isotope data. Precolonial individuals from the Antilles possess $\delta^{13}C_{ap}$ values ranging from approximately -7 to -14‰. In general, these results have been interpreted as reflecting mixed diets including minor to moderate

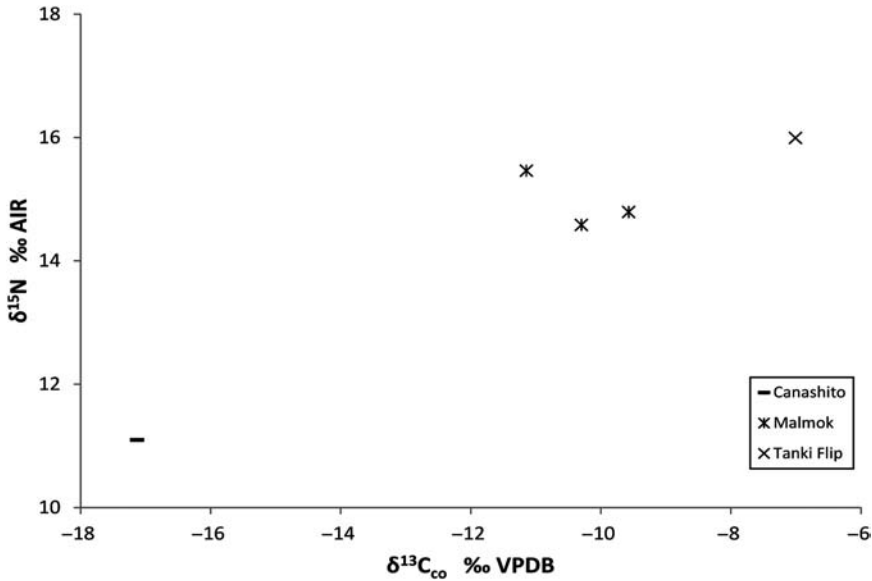


Figure 12.4 Chart of $\delta^{13}C_{en}$ results showing individual isotope values from this study compared to the mean $\delta^{13}C_{en}$ ($\pm 1\sigma$) for other precolonial sites in the Antilles. (Produced by H. Mickleburgh).

contributions of C_4 plants and/or aquatic protein sources to the whole diet of precolonial Antilleans. Notably, the Aruban data from this study are higher in $\delta^{13}C$ than almost all precolonial $\delta^{13}C_{ap}$ reported to date ($n > 350$).

The enamel $\delta^{13}C_{en}$ results from this study can be most directly compared to published $\delta^{13}C_{en}$ data (Laffoon et al. 2013) from various precolonial sites in the Antilles (Figure 12.4). Despite differences in $\delta^{13}C_{en}$ values between bone and enamel samples at certain sites (Table 12.4), the overall range and geographic patterning of the $\delta^{13}C_{en}$ data in the Caribbean are highly comparable. For example, except for a few outliers, the vast majority of precolonial Antilleans possess $\delta^{13}C_{en}$ values ranging from about -13.5 to -8‰ . As is the case relative to the bone apatite dataset, the Aruban $\delta^{13}C_{en}$ results are extremely elevated relative to $\delta^{13}C_{en}$ from all other Antillean populations analyzed to date. This pattern holds true independently of chronology, as both the Archaic and Ceramic Age samples from Aruba are substantially enriched relative to all other precolonial populations. Unfortunately, to our knowledge, there are as yet no other Archaic Age enamel or bone apatite $\delta^{13}C$ data sets from the Antilles available for comparison. Similarly, within a broader regional perspective the Aruban collagen isotopes results are also much higher in both $\delta^{13}C_{co}$ and $\delta^{15}N$ than all other precolonial populations (Figure 12.5). In fact, the geographic patterning of the Aruban collagen isotope data mirror those of the enamel and bone carbon isotope data in this

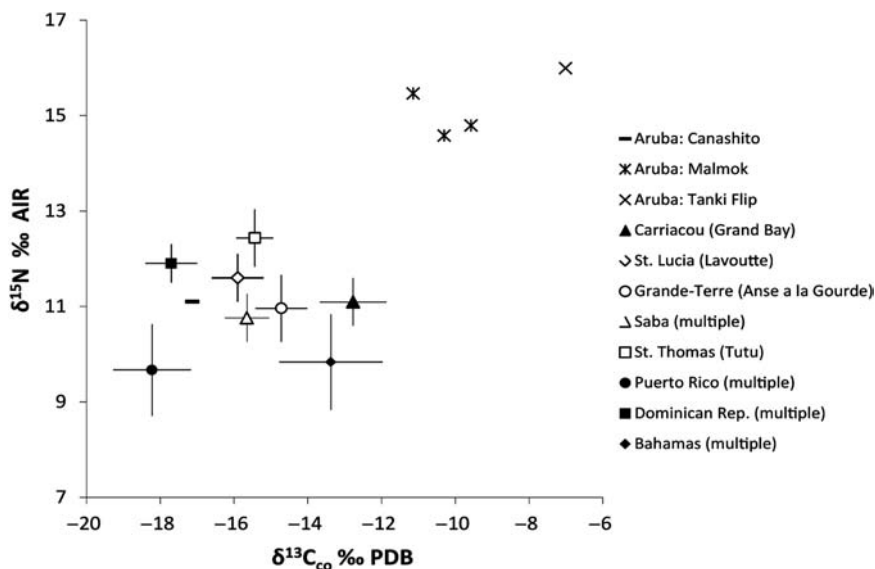


Figure 12.5 Chart of $\delta^{13}\text{C}_{\text{eo}}$ and $\delta^{15}\text{N}$ results showing individual isotope values; and the mean ($\pm 1\sigma$) for All, Archaic, and Ceramic samples separately. (Produced by H. Mickelburgh).

regard. Therefore, based on these preliminary results, precolonial dietary patterns on Aruba in both the Archaic and Ceramic Ages may have been substantially different than elsewhere in the insular Caribbean.

These dietary differences could possibly derive from higher rates of marine protein consumption on Aruba owing to a general scarcity of terrestrial animal protein sources. However, the same can also be said for various Lesser Antillean populations which, based on multiple lines of evidence, were clearly heavily reliant on marine resources and yet possess much lower collagen (and enamel) isotope values than the Aruban data reported here. Another possibility is that these precolonial Arubans were consuming greater quantities of C_4 resources than other Antillean populations, as has been observed for multiple Mesoamerican populations (e.g., Metcalfe et al. 2009; Rand et al. 2013; Somerville et al. 2013) which possess comparably elevated $\delta^{13}\text{C}_{\text{en}}$ owing to heavy reliance on maize. Additionally, other food sources with high $\delta^{13}\text{C}$ values, including C_4 plants (e.g., amaranths) or CAM plants (e.g., pineapple and agave), were available in the precolonial Antilles (Pestle 2010) and may have been consumed by precolonial Arubans. Based on the isotopic ecology of the region, it seems likely that the consumption of large quantities of (higher trophic level) marine protein in addition to some non-trivial contributions from C_4 /CAM plants would be required to produce the extremely elevated values recorded for all three isotopic proxies in this study.

As is apparent, there are clear limitations to dietary reconstructions based on isotope data alone. While various lines of evidence can be marshalled in the interpretation of stable isotope data, other relevant information obtained directly from individual skeletal remains are the most comparable and potentially most informative. Comparisons between individual enamel stable isotope results from this study and the results of previous micro-botanical research on starch grains in dental calculus (Mickleburgh and Pagán Jiménez 2012) from some of the same individuals can provide additional insights in terms of dietary assessments.

Amongst the Aruban samples included in the starch grain analyses, the Archaic Age samples (Malmok and Canashito) contained maize, cocoyam, manioc, marunguey, and sweet potato. The Ceramic Age samples (Tanki Flip and Savaneta) contained maize, marunguey, and pepper (*Capsicum* sp.). Except for maize which is a C_4 plant, all of these plants utilize the C_3 pathway and thus have very low $\delta^{13}C$. Corresponding isotope and starch grain results are available for four individuals: Canashito B3; Malmok B6; Malmok B10; and Tanki Flip B200. Of these, three out of four (except Malmok B6) possessed one or more maize starch grains in their dental calculus providing direct evidence for maize consumption. Investigating their $\delta^{13}C_{en}$ values more closely, however, reveals some disparity between the presence/absence of maize starch grains and $\delta^{13}C_{en}$ values for these three individuals. For example, of the three individuals with maize starch grains in their calculus, Canashito 3 (the nonlocal individual with possible mainland origins) has the lowest $\delta^{13}C_{en}$ value in the Aruban sample set, while Malmok B10 and Tanki Flip B200 have two of the highest values. In addition, Malmok B6 has a nearly identical $\delta^{13}C_{en}$ value to Malmok B10, but did not have any maize starch grains.

The lack of clear correlations between the two data sets may derive from the very small sample sizes and/or issues of differential preservation and identification of starch grains. Additionally, this may also simply result from the fact that the two methods vary in the types of information they provide, with starch grains indicating the presence of certain plants in the diet and carbon isotopes reflecting long-term averages of various dietary components. Nevertheless, the highly elevated $\delta^{13}C_{en}$ values of several Archaic Arubans lends further support to one of the main conclusions of the starch grain study, e.g., that people were consuming maize on Aruba much earlier than previously recognized (as early as 350 BC to AD 150). A similar conclusion was proposed in a recent study combining isotope and starch grain analyses on Archaic Age populations from north-western Cuba, based on the presence of starch grains from cultigens (beans, maize, and/or sweet potatoes) and elevated bone collagen $\delta^{13}C$ values (Chinique de Armas et al. 2015). The correspondence between multiple lines of evidence from different regions and islands indicates that the consumption of maize was quite widespread, initiated fairly early on, and may have varied in intensity and/or importance both temporally and spatially in the precolonial Caribbean.

Conclusions

The dental pathology and wear differences between the Aruban Archaic and Ceramic Age groups appear to mirror a similar shift observed in a larger regional study of Early Ceramic Age and Late Ceramic Age (Mickleburgh 2013, 2014) dental patterns. Comparisons between the two groups revealed an increase in pathology rates paired with a decrease in rate of wear over time, indicating a growing focus on refined, cariogenic foods, such as horticultural/agricultural produce. However, as noted, the difference in pathology rates is mostly due to the high rates observed at one Ceramic Age site: Santa Cruz. If we exclude Santa Cruz, the data are more suggestive of continuity in dietary practices rather than change.

Similarly, the isotope results indicate a general lack of difference in isotope values between the two groups (excluding the single nonlocal individual from Canashito), and that much of the observed chronological variation can be attributed to the specimen from Santa Cruz. This may indicate either that no dietary change occurred, or that if it did occur it is not observable from stable isotope results. However, based on the observed dental pathology rates, this is unlikely, and, as such, the combined results of our study are suggestive of continuity in diet. The reduction in food abrasiveness, observable both with and without the Santa Cruz individuals, most likely reflects changing food preparation techniques between the two periods, corresponding with the adoption of a broad set of ceramic food preparation utensils.

In summary, the preliminary bioarchaeological evidence presented here suggests that, with the exception of Santa Cruz, the Ceramic Age individuals in this study did not consume a substantially different diet from the Archaic individuals, although food processing techniques likely changed with the introduction of ceramic utensils. This adds to the growing body of evidence indicating that Archaic Age food-ways were more similar to later periods than traditionally recognized (Chinique de Armas et al. 2015; Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez 2011; Pagán Jiménez et al. 2015). In addition, based on the preliminary results of the isotope data precolonial dietary patterns on Aruba in both the Archaic and Ceramic Ages may have been substantially different than elsewhere in the insular Caribbean. However, caution must be applied, as these preliminary results are based on a small number of individuals.

In order to investigate Aruban food-ways more thoroughly further research is needed, particularly more comparative analyses of larger datasets of apatite (enamel and bone) versus collagen (dentine and bone) stable isotope results, which reflect different aspects of diet (whole diet versus protein, respectively), which, combined with analysis of dental pathology and wear, paleobotanical research, and contextual site information, will provide a better understanding of dietary and subsistence transitions over time.

Acknowledgements

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Notes

- 1 While we make use of two groups traditionally considered to be temporally and socioeconomically distinct (Archaic and Ceramic Age), our analyses are intended to investigate temporal developments in dietary practices (reflected in our samples which span a long occupation history of Aruba).
- 2 Malmok (burials 6 and 10), Canashito (burial 3), and Tanki Flip (burial 200) (Mickleburgh and Pagán Jiménez 2012).
- 3 C₃, C₄ and CAM (crassulacean acid metabolism) refer to the different forms of carbon fixation used during photosynthesis.

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Part VI

Circum-Caribbean farmers



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Florida Keys



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13 When foragers are managers

Social complexity and persistent foraging in the Florida Keys

*Traci Ardren, Victor D. Thompson,
Scott M. Fitzpatrick, Joseph Stevenson,
and Roger L. Sierra*

Introduction

The coastal populations of southern Florida in the time just prior to, and during, the moment of European contact are justifiably famous for their maintenance of nonagricultural subsistence systems despite their familiarity with agriculture as practiced in northern Florida and the Caribbean (Marquardt 1992; Newsom and Wing 2004; Thompson et al. 2013; Worth 2014). The Calusa of southwestern Florida are characterized today as a nonagricultural complex chiefdom or weak tributary based state comprising 50–60 communities spread across most of the southern peninsula (Marquardt 1988; Thompson and Worth 2011: 75). A strong case has been made that the political complexity present in south Florida, as noted by sixteenth-century Spanish chroniclers, emerged out of, not in spite of, a rich and diverse coastal resource base that has a long history of human use. The successful chiefdoms of Marco Island and the Ten Thousand Islands area of the southwestern Gulf coast employed a multifaceted coastal foraging strategy that evolved from earlier occupants of the same area. For example, as Russo's (1991, 1998) work at Horr's Island demonstrates, there is evidence of permanent coastal settlements in place for more than four millennia at the time of European contact.

As Reid et. al. note in the Introduction to this volume, “farming” may be defined in a variety of ways, including strategies for long-term management of wild natural resources for subsistence purposes. Management is, of course, a loaded term with many different meanings (see Thompson 2013), so this requires some clarification for the present discussion. Although the Calusa and their neighbors were not agriculturalists, this does not mean they were simply foragers in the sense of small-scale mobile populations extracting resources for immediate consumption (*sensu* Woodburn 1988). There are many ways in which hunter-gatherers can modify the landscape to increase productivity of certain resources. This often involves altering to some degree when certain resources become available and where they tend to be concentrated, or in other words, a deliberate engagement in anticipated surplus production (Thompson and Moore 2015). For coastal foragers, one

way they might participate in anticipated surplus production involves large-scale labor projects or technological advancements that enhance mass capture of resources (e.g., fish weirs, large scale net technologies, boats). When groups begin to invest in such activities, and are able to sustain them, this has the potential to complicate relations of production and thus present social situations where individuals or groups may garner prestige or social capital (Thompson and Moore 2015; see also Ames 1994). Given observations by Spanish colonists in southern Florida of groups with dense coastal populations and a high degree of interconnectivity, it seems that, to varying degrees, groups in this area “managed” coastal resources in such a way as to support complex social and political systems. That is, through both intentional and unintentional actions, groups in this region began to manipulate or manage where certain resources occurred in time and space, essentially managing or in some sense domesticating their landscape.

In this chapter, we ask whether archaeological data from important coastal regions adjacent to the Calusa heartland and the Caribbean can be brought to bear on the question of how persistent foragers “cultivated the land and sea” in ways that produced long-term sustainable results in the absence of agricultural reliance. We suggest archaeological data from the Florida Keys (Figure 13.1) best fit within a model of social complexity based on persistent foraging that included aspects of environmental management and soil modification.

Florida Keys

The Florida Keys are a unique environmental location that supported prehistoric coastal populations long before the arrival of Europeans in the early sixteenth century. According to firsthand descriptions from the Spanish Colonial period, the inhabitants of the Keys were organized as a distinct group who traded and shared cultural features with the Calusa of southwestern Florida and the Tequesta of the Miami area (Hann 1991). They may have even had a dependent economic and political relationship with the Calusa, although the details of that dependency are not at all clear. We still lack basic chronological information for the earliest pre-Hispanic occupation of the Keys, although nearby mainland sites in the Everglades and Miami are convincingly dated to the Archaic period (Carr 2012; Schwadron 2010). The Glades ceramic sequence established for most of south Florida by John Goggin in the 1940s and still in use today, begins with undecorated, sand-tempered pottery at 500 BC and includes three major phases that encompass the arrival of Europeans in AD 1513 (Goggin 1939, 1948, 1950). More than 150 prehistoric archaeological sites have been identified in the Keys according to the Florida Master Site File, a comprehensive database maintained by the Florida Division of Historical Resources (Figure 13.2). Most of these remain un- or under-investigated, with many having now been lost due to natural processes and modern development.

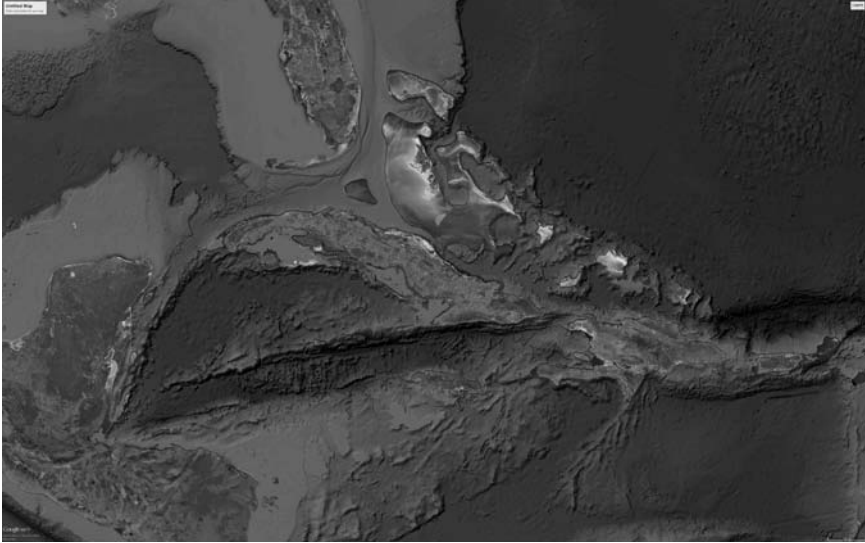


Figure 13.1 Satellite imagery of the Florida Keys and northern Caribbean. Prepared by Joseph Stevenson.

The pre-Hispanic Keys inhabitants were well adapted to a marine resource-based lifestyle, and Spanish accounts describe them as healthy and muscular canoe fisherfolk who lived in largely perishable housing. Historic evidence suggests that they were in regular contact with fisherfolk on the island of Cuba just prior to European contact in Florida, and were later employed by Spanish-Cuban fishermen (Worth 2014), though hard archaeological evidence for contact is lacking (Knight and Worth 2006). The indigenous inhabitants of the Keys were the first salvagers in the area, and as ship-borne transport increased during the colonial period, there are European descriptions of their skill with deep-water navigation and diving. Our best evidence of these coastal fisherfolk are refuse heaps or middens of food and tool remains that likely represent the residue of residential settlements. Archaeological sites in the Keys and nearby mainland are most commonly characterized by what is known as black earth middens, or a thick lens of organic rich dark soil filled with bone, some shell, and pottery fragments. The character of these middens is quite different from the naturally occurring coral rock sand that covers most of the islands, and many archaeological middens were reutilized for agricultural purposes in the modern period given their fertile organic composition. The Keys also have distinctive rock mound features not found elsewhere in Florida that are composed of large piles of unworked limestone and/or large conchs (*Busycon* usually). These features are not directly associated with middens, and their function remains unknown. Despite early attention

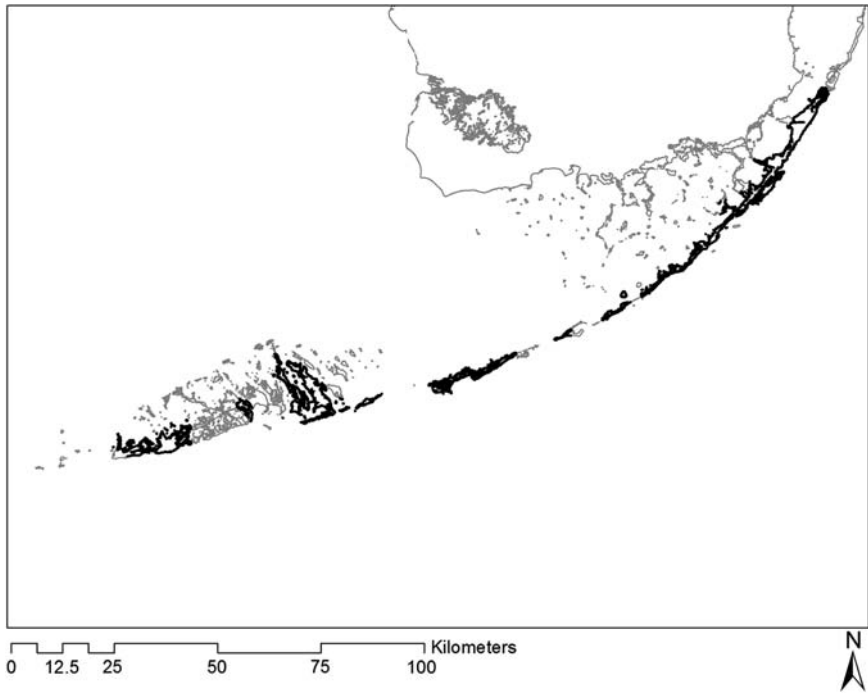


Figure 13.2 Map of Florida Keys with general location of prehistoric archaeological sites noted in black outline. Map by Joseph Stevenson.

from Caribbeanists such as Irving Rouse, and especially his student John Mann Goggin, scant archaeological investigation has been conducted in the Florida Keys despite rapid development during the twentieth century, which has destroyed or impacted numerous archaeological sites (Goggin 1948; Goggin and Sommer 1949; Siegel 1996).

Brief ethnohistoric accounts of the Keys inhabitants do not provide sufficient detail to understand how choices were made to manage certain scarce natural resources, neither do archaeologists have a sufficient understanding of the scale and organization of these populations. Given the wealth of data to emerge from new research on the Calusa chiefdoms over the past 15 years, a better framework now exists for understanding past choices and adaptations in the material remains of the pre-Hispanic people of the Keys, known as the Matecumbe in sixteenth-century Spanish accounts. Little previous research has been conducted to establish the resource base or subsistence patterns of prehistoric Keys inhabitants, and models often assume a resource strategy parallel to that of the Calusa. However, many features of the Keys archaeological sites are quite different than those of the Calusa, in particular the low frequency of shellfish remains

at sites in the island chain. The Calusa accumulated shellfish remains (presumably after consuming the flesh) for a variety of purposes, including the creation of anthropogenic islands and large-scale midden-mounds, some of which were over 10 meters high. But shell comprises only a small percentage of the material found at Matecumbe sites, and there appear to have been only one or two locations where monumentality or construction that exceeded the practical requirements in either scale or elaboration was attempted (Pluckhahn and Thompson 2014; Trigger 1990). The deep water location of the Keys made shellfishing more challenging than it was along the Gulf of Mexico, suggesting that terrestrial resources and deep-water fishes may have played a larger role in the Keys subsistence systems. The large number of sites identified in the Keys also argues for a resource management plan that involved components other than the myriad of shellfish and shallow bay system fish so easily available and accessible to the Calusa.

Environmental background

The Florida Keys are a coral reef archipelago of more than 1,700 environmentally distinctive islands. These low limestone islands, with average elevations of less than 1.5 m above sea level, extend 225 km southwest of the mainland (McPherson and Halley 1996). The archipelago forms a boundary between the relatively shallow waters of Florida Bay to the northwest, and the Straits of Florida to the southeast. A narrow shelf is present along the eastern or southern side of the island chain where the seafloor drops sharply into the Atlantic. The Florida Keys receive less rainfall than many other parts of coastal southern Florida, on average 40 inches annually, primarily during the summer months (McPherson and Halley 1996: 8). These levels are similar to those found in the interior of the Florida peninsula around Lake Okeechobee. Like the entire southern tip of the Florida peninsula, from Charlotte Harbor on the west coast to the northern end of Biscayne Bay on the east, the pre-development Florida Keys were characterized by the presence of estuarine environments with open water and unconsolidated shorelines. Throughout this area, the gentle slope of the West Florida Shelf provides a broad, shallow zone where brackish water from the Everglades mixes with marine water of the Gulf of Mexico to support rich estuaries of semitropical mangrove forests filled with oyster bars, wading birds, fishes, and marine mammals. Culturally significant terrestrial mammals endemic to the Keys include the Key deer, panther, bobcat, raccoon, rabbit, opossum, squirrel, and a variety of rodents (Lazell 1989). Sea levels have been rising continually in south Florida over the past 6,000 years, with measurements in Key West indicating a rise in sea level of 30 cm or so since 1850 (Maul and Martin 1993). Such dramatic changes in coastal conditions have obvious implications for the identification and investigation of pre-Hispanic occupations in the region.

Prior archaeological research

Original excavations in the Keys by John Mann Goggin and his fellow Yale graduate student Frank Sommer, are well known in the history of Florida and Caribbean archaeology. Goggin grew up in south Florida and explored the archaeological sites of the Keys and Everglades for many years prior to entering graduate school to work with the famous Caribbeanist, Irving Rouse. According to biographer Brent Weisman, Goggin persuaded Rouse and the Caribbean Anthropological Program at Yale to fund the first excavations in the Keys immediately after being accepted into the graduate program, before he had even begun classes (Weisman 2002: 67). Goggin was interested in cultural relationships between Florida and the West Indies and knew the rich midden sites of the upper and middle Keys were strong candidates for scientific investigation. Goggin's excavations remain the only sustained program of terrestrial archaeological research in the Keys, although rapid development since the 1970s has necessitated constant monitoring by cultural resource management firms who have done an admirable job of chronicling the region's loss of archaeological material and sites (for example, Carr and Beriault 2009; Carr et al. 2009; GAI Consultants 2009).

Goggin's 1940s era excavation data from the Keys defined south Florida pre-Hispanic cultures for three decades until research was conducted around Lake Okeechobee in the interior of the state and at the mouth of the Miami River. Stark contrasts between the material culture of these three areas showed that the Keys had more in common with the pre-Hispanic cultures of the mainland near the Miami River, but the low black earth middens filled with animal bone in the Keys were clearly distinct from the large shell middens of the southwestern coast or earthworks around the Lake. Current taxonomic models place the Keys as a sub-region within the Glades culture, which is defined as a set of shared cultural features found in the Everglades, Ten Thousand Islands, and Florida Keys; however, this model is based on limited data and subject to change (Ardren et al. 2016; Carr and Beriault 1984; Milanich 1994). Ceramic styles suggest the Ten Thousand Islands may be a distinct cultural area, and the relative lack of investigation in the Keys makes it possible that they too were a sub-region within the Glades cultural area. An earlier notion that south Florida cultures relied more heavily on vertebrates because they were non-agricultural has been largely disproven based on the quantification of similar faunal diversity and prevalence in middens throughout the state (Griffin et al. 1985; Milanich 1994: 279).

Matecumbe Chiefdom Project

The authors recently began research at one of the core sites in the Florida Keys with the intention of understanding natural resource management choices in prehistory. These choices have implications for the scale and organization of Keys populations. In this pilot project, we revisited an

important site on Upper Matecumbe in the central Florida Keys to provide new insight into how the occupants of this possible village differed in terms of their ecological adaptations from other groups in southern Florida. Such a comparison will provide a strong basis for an initial evaluation of Spanish ethnohistoric accounts that the Matecumbe or Keys Indians were an independent chiefdom who paid tribute to the Calusa. The site at Upper Matecumbe Key (8MO17), recently designated the Clupper Site, was important in the development of the southern Florida ceramic chronology. The site is quite large at ca. 85 m × 52 m, with up to 1.2 m of midden deposits in various locations (GAI Consultants 2009: 72; Goggin 1944: 19). Most importantly, the site has deposits dated to many major periods in the Keys' region, including Glades IIa (AD 700–900), IIb (AD 900–1000), IIc (AD 1000–1200), IIIa (AD 1200–1400), and IIIb (AD 1400–1513). Thus, Upper Matecumbe Key represents an ideal site to examine material culture and subsistence change over time and how Keys area traditions may have shifted or differed in terms of larger environmental and social conditions.

To provide baseline data for understanding settlement chronology and change over time for 8MO17, we conducted a shovel test pit survey in early December 2014. We excavated standard 50 cm × 50 cm squares in 10 cm levels and soil was dry-sieved through 1/8 inch (0.32 cm) wire hardware cloth. Excavation in the midden and adjacent to looters pits was highly productive, and excavation proceeded for 70–80 cm below ground surface but did not reach bedrock or the water table, which was expected at closer to 1 m below the surface (Figure 13.3).

Beneath the initial levels that contained Euro American historic and modern artifacts, the matrix was free of modern or historic contamination and materials dating to the Glades II period (AD 750–1100) were plentiful. As noted by Goggin and Sommer (1949) and others (Carr et al. 2009) who have excavated black earth midden sites in the Keys, below the initial 25–30 cm, the matrix became increasingly compacted and cemented together with lime deposits. This material was not as impenetrable as the calcrete duricrust layer known from midden sites in the Everglades (Schwadron 2006), but rather was a dense lens of primarily faunal remains (mostly bone) with some shell and ceramic material amalgamated together in a binding matrix of grey lime or calcrete.

Faunal material dominates the samples. Although faunal analysis is just beginning, raw weights of the various classes of recovered materials demonstrate that vertebrates far surpass the quantity of shell, ceramics, or lithics. A preliminary assessment suggests high percentages of bony fish, turtle, and bird remains, with little deer or other mammals. Shell was less plentiful than at other black earth midden sites in the Keys, in part due to extensive scavenging for large conchs and tools visible from the surface. The most common shells were marine gastropods, dominated by *Busycon* and *Lobatus gigas* (formerly *Strombus gigas*), some of which were modified into tools, as well as *Nerita* spp. and *Cittarium pica* (West Indian top snail). Very few bivalves

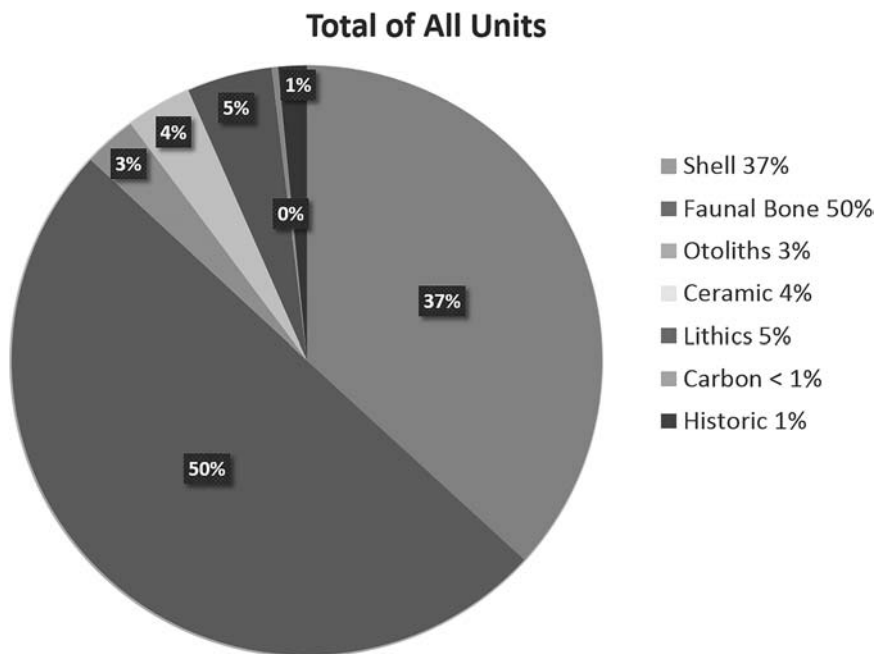


Figure 13.3 Percentage of cultural remains by weight at MO17. Chart by Roger Sierra.

were recovered and certainly did not represent as significant a component of the diet for the inhabitants of this midden site as familiar species such as oyster and clam did for the Calusa along the west coast. Further malacological analysis is currently underway.

Some 305 ceramic sherds were analyzed from the four shovel tests. More than two-thirds of those sherds were Glades Plain or plain body sherds from decorated pottery. Glades Plain is the ubiquitous south Florida version of sand tempered plain ware, a form of pottery produced throughout the entirety of prehistoric ceramic production, or from at least 500 BC into the sixteenth century. The other one-third of the ceramics recovered were rim sherds and/or decorated sherds with diagnostic details. Most common was Key Largo Incised which dates from Glades IIa–IIb or AD 750–1100. Other relatively common types included Matecumbe Incised which appears in Glades IIb (AD 900–1100) and Miami Incised which was used during Glades IIa (AD 750–900). There was little chronological range in the materials we recovered, and the Glades I and Glades III materials reported by Goggin for this site did not seem to be present, except perhaps a couple of Glades tooled rims that date to Glades IIIb. One of the primary objectives of returning to the Clupper site was to correlate the ceramic sequence first identified by

Goggin with radiometric dates. A wide array of carbon-14 tests on both faunal bone and shell are underway. A single sample of *Codakia orbicularis* from level 6 of shovel test 4, 55–65 cm below the ground surface, submitted to Beta Analytic for AMS dating, yielded a calibrated date of 1280+/- 30 BP (Beta – 410911, 2 sigma calibration AD 1065 to 1235/Cal BP 885 to 715). This absolute date range correlates well with the predominantly Glades II ceramic materials.

Comparative perspectives

Given the limited information that we have regarding the archaeology of the Keys, it is difficult to make any but the most broad scale comparisons. With that said, the limited information that we do possess seems to indicate significant differences and point towards a unique Keys solution to sustainable occupation and food insecurities in the region. The first and most obvious observation is that the Keys were likely never as densely occupied as the estuaries and shallow bays of the southwestern Gulf Coast, particularly those in the core Calusa area. We at least know this to be the case during the early historic period, as sixteenth-century accounts suggest that pueblos, or towns, in the domain of the Calusa were relatively small—especially those around the Lake Okeechobee area and that of the Keys. The primary basis for this observation is the account of the shipwrecked Spaniard Hernando de Escalante Fontaneda, who served as Pedro Menéndez de Avilé's translator to the king of the Calusa and who lived among the Native peoples of southern Florida for 17 years (Worth 2014). Fontaneda's list of 37 of some 50 settlements includes at least 2 in the Keys area, including Guarugunbe and its subordinate Cuchiaga (Worth 2006). The former may refer to not only the town, but also the polity that was subject to the Calusa capital. If this is the case, the total population for this Keys polity was around 1,000, with the populations of towns not exceeding 100 based on López de Velasco's notes on Fontaneda writings (Worth 2006: 5; 2016). In contrast, populations of the largest towns in the Calusa heartland, near Estero Bay, likely reached around 400 or 500. This is, in fact, the estimate for the pueblo of Tampa, the Pineland site, which Marquardt and Walker (2012, 2013) posit for this large site on Pine Island near modern Charlotte Harbor. The Calusa capital of Calos, the Mound Key site, is estimated to have a much larger population and according to Spanish documents the population at the site was around 1,000 in 1697 (Marquardt and Walker 2013: 854; Hann 1991: 168). It is possible that the population of Mound Key was even larger, possibly as much as 1,500 during the sixteenth century, given the description of the king's house and the recent archaeological identification of a large structure on top of Mound 1 at the site (Thompson and Marquardt 2015).

The ethnohistoric descriptions of settlement size seem to track with the nature of site size in the Keys and Calusa heartland. In general, the largest Keys sites do not compare with the largest ones of the Ten Thousand Islands, Charlotte Harbor, or Estero Bay areas of the southwestern Gulf Coast.

The largest of these sites are complex midden-mound landscapes, many around 20 hectares in size, with some like Mound Key and Fakahatchee Key exceeding 40 hectares (Schwadron 2010, 2013; Thompson 2017). Another key difference between these sites and Keys settlements is that the larger Calusa sites often have observable regular elements that are incorporated into their site plans that seem to exhibit symmetry, axuality, and orthogonality into their layouts (Thompson 2017). While some of these relationships among features at these sites appear planned, others seem to be an outgrowth of regular site use (Thompson 2017). In contrast, we know little about the architecture at the smaller Keys sites. However, likely due to their much smaller populations, the nature of their subsistence strategies (i.e., the lack of a focus on shellfish and other mollusks), they had less of a need to structure the layout of their settlements in such a way.

While it seems that there are considerable differences between Keys sites in terms of population and size compared to those in the Calusa heartland, there are some important similarities among Keys sites and others in southern Florida that relate to our points regarding the possible management of resources in the region. Based on our current chronologies, there appears to be great continuity in site use over time. Upper Matecumbe Key (8MO17) has evidence of occupation for every major Glades period. Similarly, other southern Florida sites in the Okeechobee Basin, as well as those along the southwestern coast, indicate site use and reuse over extend periods of time (ca. 1,000 years) (Marquardt and Walker 2012, 2013; Thompson and Pluckhahn 2012). Work at these and other sites in the basin and along the coast indicate a considerable manipulation of the natural landscape in terms of forest clearing and the flow of water, perhaps to concentrate resources (Marquardt and Walker 2013; Thompson and Pluckhahn 2014). While again we have little information regarding the nature of such activities at Keys sites, the fact that sites such as 8MO17 indicate long-term use suggests that at the very least some form of resource management took place in order to facilitate sustainable occupations of these places on the landscape.

What is observed in the Keys prehistorically in many ways stands apart from what has occurred in the Caribbean islands over the last two millennia or so. While it was once thought that horticultural activities were limited to primarily manioc (*Manihot esculenta*), which developed only after the arrival of Saladoid migrants ca. 500 BC, it is now known that Archaic groups before this were actively managing numerous species of both native and non-native plants (see Newsom and Wing 2004). More sophisticated analyses on a variety of sample types such as lithic artifacts (e.g., Berman and Pearsall 2008; Pagán Jiménez et al. 2015) and microbotanical remains such as phytoliths trapped in calculus from teeth (Mickleburgh and Pagán Jiménez 2012), clearly show that there was much greater cultigen diversity than presumed. These included the presence of sweet potato (*Ipomoea batatas*), maize (*Zea mays*), and a host of other cultivars that were both found locally

or brought into the Caribbean from elsewhere. Surprisingly, in the study conducted by Mickleburgh and Pagán Jiménez (2012), which included 30 samples from 14 pre-Columbian sites on 10 different islands, there was little evidence found for manioc, suggesting that other crops such as maize and marunguey (*Zamia* sp.) were much more important.

While there is increased recognition that Caribbean natives in the past were managing and consuming numerous plants (mostly tubers), it is unclear how these activities affected local landscapes and ecologies, including marine environments that were of considerable importance to the livelihoods of indigenous groups (Newsom and Wing 2004). Some evidence suggests that native peoples impacted shellfish beds, finfish populations, and possibly other animals, but whether this resulted from horticulture is tenuous (Fitzpatrick and Keegan 2007). Landscape transformation like that seen in the Keys and other parts of South Florida with mound building, shell rings, etc. have not been recorded in the Caribbean, despite heavy utilization of marine resources and increased levels of social complexity like that of the Taíno in the northern Caribbean, that ultimately led to widespread and intricate exchange relations and social connections between the islands and parts of northern South America (e.g., Hofman et al. 2008).

Persistent foraging model

While located in a rich estuarine environment, the pre-Hispanic occupants of the Keys did not have access to the predictable and plentiful mollusk and shallow bay fish resources of the Gulf of Mexico, where their neighbors the Calusa achieved a high degree of social complexity based on the management of non-agricultural resources. However, the large number of archaeological sites and the continued long-term use of certain locations (including 8MO17) indicate that this region was able to support a relatively high population density in the island chain during at least the last millennia prior to European arrival, which likely had a long-term impact on the marine ecosystem. There are several ways that Keys inhabitants may have accomplished these patterns. Shifting sedentism could have mitigated these impacts and the effects of resource depletion (e.g., see Erlandson and Rick 2008: 7), but to date models have not suggested seasonal occupation of the Keys (Carr 2012; Carr and Beriault 1984; Milanich 1994). Cultural practices and technological innovation that encouraged conservation or sustainable concentrated harvests also would have facilitated the long-term occupation of the Keys. Data from nearby regions of southern Florida suggest that the ability to sustain permanent settlements was in place during the Archaic period. Careful management of natural resources such as fresh water, fuel, and food would have been essential for the indigenous population of the Keys.

Foragers are well known to use mobility as a means of acquiring the complex data needed to monitor, collect, and process information about available resources as a part of landscape learning (Kelly 2003; see also Andrus and

Thompson 2012). Mobility allows the acquisition of comparable information from diverse locales that helps foragers to make appropriate choices (Fitzhugh and Habu 2002). Risk is managed by increasing the amount of information about resource availability, and this is often accomplished through an expanded range or frequency of movement. Spanish descriptions of the indigenous occupants of the Keys depict these fisherfolk as highly mobile, expert maritime navigators. Resource hot spots are also key components of a predictable wild foods subsistence system. Natural fresh water wells were located on only two of the islands of the Keys, both of which have extensive prehistoric settlement in the immediate area. Likewise, the Clupper site midden, one of the most extensive prehistoric middens in the Keys, is adjacent to Indian Key Channel, a natural deep-water channel that provided one of the only navigable passes from Florida Bay to the Atlantic for Spanish colonial ships. The deep waters and active currents of this pass are resource rich with large bony fish species not found in shallow waters. Persistent foragers are those that reconnoiter a known food source frequently to ascertain its status, relying on a deep knowledge of local conditions and optimal outcomes. The reliance on large bony fish demonstrated in the faunal sample from the Clupper site midden, as well as elsewhere in the Keys, suggests a mobile population of persistent foragers who managed a mosaic of food production strategies such as fishing, collecting, and hunting adjacent to resource hot spots. The exploitation of a range of resources and environments would protect against overexploitation and serve effectively as a type of resource management, allowing a certain degree of knowledge and management over where resources were concentrated in both time and space over the landscape. Such practices would have buffered against food insecurities and allowed Keys inhabitants to continually occupy and reoccupy specific sites. Furthermore, such management practices would have also allowed them to predict or anticipate when larger surpluses of food could be procured, thus supporting the more complex forms of social and political relationships (i.e., chiefdoms) indicated by ethnohistoric documents of the region. In sum, the persistence of Keys systems, despite contact with more complex resource management systems in the Calusa area and possibly in the Caribbean, argues for a unique Keys history and solution to food security and resource management. This conclusion provides archaeologists with yet another narrative to understand the broader managed mosaic of Native south Florida ecological practices in this region.

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14 Maize, manioc, mamey, and more

Pre-Columbian lowland Maya agriculture

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Introduction

Until the latter decades of the 20th century, many scholars—predominantly from temperate-climate habitats—viewed the tropical forest environment of the Maya Lowlands as a limiting factor in the development of complex civilization. In the past half century, scientists have come to perceive the lowland environment in ways analogous to those of its indigenous inhabitants: a mosaic of habitats posing a wide range of opportunities and constraints to agriculture, settlement, and urbanization (Dunning and Beach 2004; Fedick 1997; Wiseman 1978). Modern scholars now also recognize that the Maya were adapting to an environment that changed over time (Beach et al. 2015b).

An Old World visitor to the Maya Lowlands in the Preclassic, Classic, or Postclassic periods would have encountered not only a wide variety of agricultural landscapes but also a world devoid of the effects of the human-grazing animal complex, because agro-pastoralism and the extensive clearing of forests to create grasslands was not introduced until the Spanish Conquest (Graham 1996; Melville 1994). The absence of agro-pastoralism—and the large-bodied mammals on which it depends—almost alone argues for greater dependence in the neotropics on plant foods and the maintenance of diversity of resources (Graham 1999: 187–188), though animal protein from wild animals, nearly domesticated deer, and domesticated ducks and turkey was certainly a part of Maya diets (Emery and Thornton 2008). Agricultural landscape variability also reflected differences in the neotropical lowland environment across space, as well as changing Maya adaptive strategies over time (Figure 14.1). Spatial variation in Maya adaptive patterns depended on several key factors including whether strategies were focused on dry upland or wetland habitats, how the Maya dealt with annual dry season water constraints, and differences in drainage and soil fertility and their management (Dunning et al. 1998a). Temporal variation reflected differences in population levels and densities, especially with urbanization, and

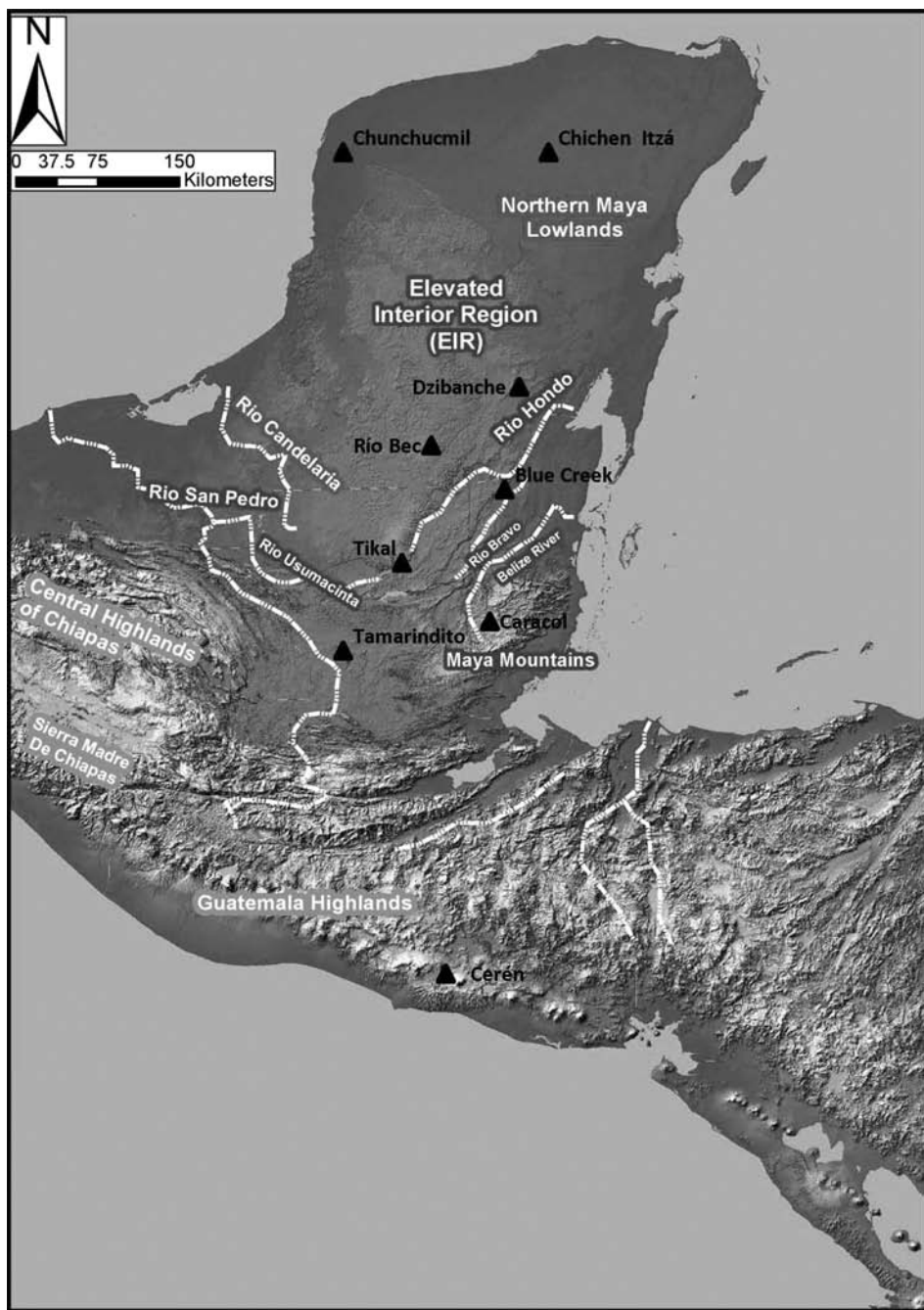


Figure 14.1 Map of the Maya Lowlands showing places mentioned in the text. (Created by N. Dunning).

changes in political economic organization. In this chapter we review both temporal and spatial variation in Maya agriculture and forest management. We highlight a few sites and regions to paint a broad picture of the ancient lowlands, but we recognize the tremendous gains in understanding that have taken place over the past few decades.

Archaic and Preclassic beginnings

The onset of sedentary life in the Maya Lowlands was coincident with the domestication of crops together known as the “Mesoamerican triad”: maize (*Zea mays* L.), several species of beans (*Phaseolus* spp.), and at least two species of squashes (*Cucurbita* spp.). Maize in particular became engrained in the Maya cultural psyche, and its cultivation became tied to human identity and divinely sanctioned rulership in Maya culture. Nevertheless, from an early time, the Maya drew upon a wide array of seed, root, and fruit crops in support of settled life.

Evidence from an Archaic rock shelter in Honduras in the middle Holocene tells us that people were already processing several plants that came to be crops in the later Holocene (Morell-Hart et al. 2014). Farmers initially grew many crops in openings cut and burned amidst the forest, a system that became known as *milpa* (swidden field) and involved the use of fields for about 2 years before being forest-fallowed for 15–20 years (Nigh and Diemont 2013). Milpas remain an important form of cultivation among the Maya today in areas where land pressure is low. Milpas probably also played a role in periods of higher population density so long as some land remained open between towns and cities, although fallow periods likely were progressively shortened—a process that threatened sustained soil fertility, most notably phosphorus levels. Phosphorus is the nutrient in shortest supply in lowland soils (Beach et al. 2015b; Dunning et al. 2012; Lawrence et al. 2007; Turner and Sabloff 2012). As will be discussed later, the lowland forests do not appear to have ever disappeared entirely. Indeed, the Maya depended on their forests as well as their savannas for fuel, construction materials, game, and other foodstuffs.

With population growth, innovation, and urbanization through the Preclassic period, more intensive forms of agriculture emerged, though their diachronic evolution is still in question (Luzzadder-Beach et al. 2016). One form of intensification was terracing. For many studied catchments, soil erosion peaks not with maximum population numbers (typically in the Late Classic) but instead during the first centuries of forest clearance and agricultural expansion in the Preclassic (Anselmetti et al. 2007; Beach et al. 2003, 2015b; Dunning et al. 1998b; Dunning and Beach 2000, 2010; Galop et al. 2004). Evidence suggests that early farmers or pioneers were less conservative when land pressure was slight or when they were in pioneer stages of agricultural understanding, a phenomenon that has been observed in many contexts globally (e.g., Fisher et al. 2009). This relationship sometimes

produced catastrophes, such as the erosion that resulted when sloping, unprotected land was subjected to intense tropical rainfall (Beach et al. 2006, 2008, 2015b). By sometime in the Late Preclassic period, soil conservation measures such as terracing began to appear in some areas (Beach et al. 2006, 2008; Carozza et al. 2007; Dunning and Beach 2000; Dunning et al. 2009; Garrison and Dunning 2009; see also further discussion later).

Anthropogenic land use changes in the Preclassic also had lasting impacts on local and regional hydrology. Forest clearance, agriculture, and quarrying triggered erosion on sloping land surrounding closed depressions (*bajos*) in the southern Maya lowlands, and the resulting sedimentation often resulted in the blockage of groundwater recharge of once perennial wetlands (Beach et al. 2003, 2008; Dunning et al. 2002, 2006; Hansen et al. 2002). Sedimentation, possibly eutrophication, and climate drying all likely contributed to the long-term transformation of many perennial wetlands and shallow lakes within *bajos* into seasonal swamps in which deep clay vertisols developed. Although many wetlands, or parts of wetlands, were “degraded,” other parts were actually enhanced from a Maya point of view. Wide aprons of calcium-rich colluvial and alluvial sediment derived from upslope erosion accumulated along the margins of *bajos*. These aprons of deep, high-base-status soils developed into some of the best agricultural land available in the southern lowlands and became the focus of intensive cultivation (Beach et al. 2015b; Dunning et al. 2002, 2006; Gunn et al. 2002).

Wetland agriculture may have started in the Archaic period (Pohl and Bloom 1996) near the Belize coast in the frontline of Holocene sea level rise as dry lands turned to wetlands. As this wetland front proceeded inland, more low lying areas became wet, perennially or nearly perennially in floodplains and depressions often along low-gradient river systems of the coastal margins of northern Belize and southern Mexico. Here, Maya farmers built wetland fields with drainage ditches and raised platforms in some areas that resurrected erstwhile dry land farms into wetland fields. Farther inland near places like Blue Creek, most evidence for intensive uses of wetlands is in the Late Classic, though other evidence suggests a Late Preclassic start, when sea level rise inundated floodplains of low-gradient rivers in the coastal lowlands of Belize and Campeche, Mexico (Beach et al. 2009, 2015a, 2015c; Luzzadder-Beach and Beach 2009; and see further discussion later).

The Classic period: feeding and fueling urban centers

By the Classic period, Maya agriculture had multiple components that included substantial production within urban areas as well as hinterlands. Within towns and cities, many households produced foodstuffs among other activities. The small Late Classic village of Joya de Cerén, El Salvador provides the best evidence discovered to date concerning the nature of ancient Maya agriculture (Sheets 2002, 2005). A volcanic eruption around AD 600 rapidly buried the community in ash, preserving both homes and gardens

(Figure 14.2). Excavations over many years within the ancient village have revealed areas of intensive garden production that included small plots of maize, the root crops manioc (*Manihot esculenta* Crantz.) and malanga (*Xanthosoma sagittifolium* (L.) Schott), as well as beans, squashes, hog plum (*Spondias* spp.), avocado (*Persea americana* Mill.), guava (*Psidium guajava* L.), calabash (*Crescentia cujete* L.), and cacao (*Theobroma cacao* L.), among other species (Lentz and Ramírez-Sosa 2002; Sheets 2005). These excavations have helped make clear that although the Maya relied on maize, beans, and squash, they grew a multiplicity of crops, including several types of root crops (see Table 14.1). Gardens were clearly carefully planned and well-tended. The tradition of household gardens (*solars*) with fruit trees, water sensitive plants such as peppers and tomatoes, as well as small plots of staples crops survives in many Maya towns today. In addition, evidence from Cerén clearly shows that the residents were practicing ridge and furrow cultivation, a soil management technique not previously observed in the archaeological record in the Maya Lowlands. More recently, investigations have been extended into land beyond the margins of the village site and have revealed extensive buried fields of maize and manioc (Sheets et al. 2011, 2012). While manioc has been posited as a major crop in Mesoamerica, archaeological data had been previously lacking to support this hypothesis.

Since the cultivation of manioc and other root crops does not involve pollination and the plants naturally produce little pollen, its absence in most archaeological pollen studies is not surprising. Nevertheless, examples of manioc and other root crops are increasingly being found in pollen and macrobotanical records (e.g., Akpinar-Ferrand et al. 2012; Dunning et al. 2002; Lentz et al. 2014a, 2015). Recovery of pollen from *aguadas*—present-day ponds that are the remains of urban and rural reservoirs—has increased the representation of low-pollen species, including many fruit trees, such as mamey (*Pouteria sapota* [Jacq.] H.E. Moore & Stearn) and sapodilla (*Manilkara zapota* [L.] P. Royen), in the documentation of ancient Maya agriculture and arboriculture in proximity to ancient residential areas (c.f. Ford and Nigh 2009).

An interesting part of thinking about Maya agriculture has been the idea of the garden or green city (Arensberg 1980). Certainly Maya cities had many gardens and other types of agriculture given the evidence from Cerén (Sheets 2005), Caracol (Chase et al. 2013), Tikal (Lentz et al. 2014a), and the fact that greenspace appears to have been an integral part of the urban landscape (Graham 1996, 1999). The concentration of food production within or near Maya urban centers is often said to be a consequence of the limits of bulk transportation to that which can be carried on the human back. This explanation does not accord well, however, with the historical persistence of urban agriculture globally nor with its modern resurgence (Mumford 1961; RUAF 2000; Viljoen 2005). Two factors contribute to our limited conceptual repertoire in accounting for urban agriculture: one is that models for what is “urban” are not rooted in any of the cultural or agricultural traditions of

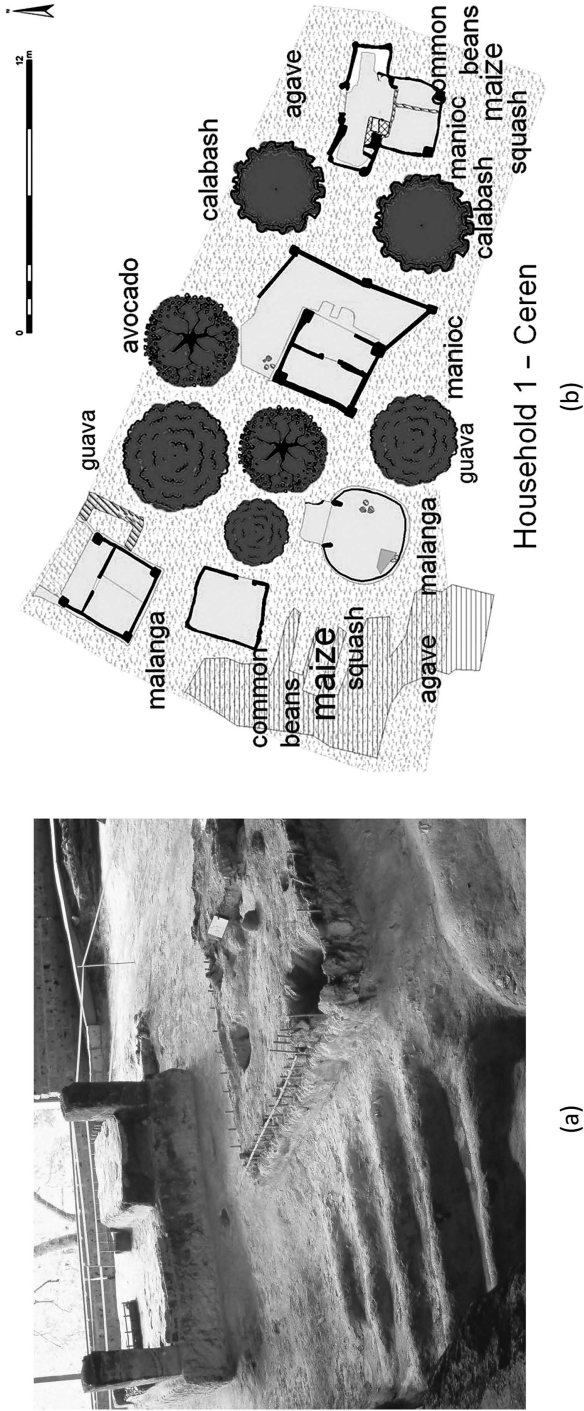


Figure 14.2 Household 1, Ceren, El Salvador: a) ridges in the foreground are the remains of ancient garden plots rapidly buried by volcanic ash along with the house structures; ridges are about 15 cm high and 30 cm apart, crest to crest (photo by D. Lentz); b) map of the crops and trees revealed around Household 1 (created by D. Lentz).

Table 14.1 Archaeological plants of the ancient Maya (Cavallaro 2013; Hood 2012; Lentz 1999; Lentz et al. 2012, 2014a, 2014b, 2015; Morchart 2011; Slotten 2015)

Annual crops [common name]	Other useful plants [common name]	Other useful plants (cont.) [common name]
<i>Agave</i> sp. [agave]	<i>Amaranthus</i> sp. [amaranth]	<i>Physalis angulata</i> [tomatillo]
<i>Capsicum annuum</i> [chili]	<i>Arundinella</i> sp. [rabo de gato]	<i>Phytolacca</i> sp. [wild calabash]
<i>Cucurbita</i> spp. [squash]	<i>Baltimora recta</i> [flor amarilla]	<i>Plantago</i> sp. [plantain]
<i>Gossypium hirsutum</i> [cotton]	<i>Brassica</i> sp. [mustard]	<i>Portulaca oleracea</i> [purslane]
<i>Lagenaria siceraria</i> [bottle gourd]	<i>Bromelia balansae</i> [pinuela]	<i>Randia</i> sp. [tují]
<i>Phaseolus</i> spp. [lima bean]	<i>Cladium jamaicense</i> [razor grass]	<i>Rivinia</i> sp. [tropical pokeweed]
<i>Sechium edule</i> [pataste]	<i>Convolvulus</i> sp. [bindweed]	<i>Rubus</i> sp. [blackberry]
<i>Zea mays</i> [maize]	<i>Crotalaria</i> cf. <i>sagittalis</i> [rattlebox]	<i>Sapium</i> sp. [leche maría]
Root crops [common name]	<i>Croton</i> sp. [hierba de jabali]	<i>Schoenocaulon officinale</i> [cebadilla]
<i>Canna</i> cf. <i>indica</i> [achira]	cf. <i>Cycloloma atriplicifolium</i> [winged pigweed]	<i>Scirpus</i> sp. [bulrush]
<i>Ipomoea batatas</i> [sweet potato]	<i>Cyperus canus</i> [tule]	<i>Scleria</i> sp. [nutrush]
<i>Manihot esculenta</i> [manioc]	<i>Dasyllirion</i> sp. [sotol]	cf. <i>Senna</i> sp. [senna]
<i>Xanthosoma sagittifolium</i> [malanga]	<i>Drymaria cordata</i> [chickweed]	<i>Sida</i> sp. [escobilla]
Tree crops [common name]	<i>Dysphania</i> sp. [goosefoot]	<i>Solanum</i> sp. [nightshade]
<i>Acrocomia aculeata</i> [coyal]	<i>Echinocloa</i> sp. [barnyard grass]	<i>Spilanthes</i> cf. <i>acnella</i> [paracress]
<i>Anacardium occidentale</i> [cashew]	<i>Euphorbia graminea</i> [spurge]	<i>Syngonium podophyllum</i> [arrowhead]
<i>Amora</i> sp. [sourpop]	<i>Fimbristylis dichotoma</i> [forked fimbry]	cf. <i>Talinum fruticosum</i> [waterleaf]
<i>Bactris major</i> [biscoyo]	cf. <i>Fimbristylis ferruginea</i> [indian fimbry]	<i>Tecoma stans</i> [flor amarilla]
<i>Bixa orellana</i> [achiote]	<i>Hamelia patens</i> [scarlet bush]	<i>Thevetia abouai</i> [cocheton]
<i>Byrsonima crassifolia</i> [nance]	<i>Helianthus annuus</i> [sunflower]	<i>Tithonia rotundifolia</i> [Mexican sunflower]
<i>Carica papaya</i> [wild papaya]	<i>Hirtella</i> sp. [pigeon plum]	<i>Trachypogon spicatus</i> [speargrass]
<i>Crescentia</i> spp. [calabash]	<i>Indigofera suffruticosa</i> [indigo]	<i>Typha</i> sp. [cat-tail]
<i>Erythrina</i> spp. [tiger wood]	<i>Melampodium</i> sp. [flor amarilla]	<i>Vigna</i> sp. [frijol]
<i>Gliricidia sepium</i> [madre de cacao]	<i>Mollugo verticillata</i> [carpetweed]	<i>Vitis tiliifolia</i> [wild grape]
<i>Muntingia calabura</i> [capulín]	<i>Morinda</i> sp. [pinuela]	
<i>Persea americana</i> [avocado]	<i>Oenothera</i> sp. [evening primrose]	
<i>Pouteria sapote</i> [sapote]	<i>Oxalis</i> sp. [wood sorrel]	
<i>Prunus</i> cf. <i>brachybotrya</i> [cerezo]	<i>Panicum</i> sp. [grass]	
<i>Psidium guajava</i> [guava]	<i>Paspalum</i> sp. [virgin grass]	
<i>Spondias</i> spp. [jocote]	<i>Passiflora</i> sp. [passion flower]	
<i>Theobroma cacao</i> [cacao]	<i>Piper</i> sp. [cordoncillo]	

(Continued)

Table 14.1 (continued)

Trees [common name]	Trees (cont.) [common name]	Trees (cont.) [common name]	Trees (cont.) [common name]
<i>Acacia</i> sp. [subín]	<i>Colubrina aborescens</i> [greenheart]	<i>Jacaranda</i> sp. [jacaranda]	<i>Rauvolfia</i> sp. [tek-ta-men]
<i>Acinthus aborescens</i> [hollow-heart]	<i>Corchorus siliquosus</i> [escobillo]	<i>Jatropha guameri</i> [pomolche]	<i>Rhizophora mangle</i> [red mangrove]
<i>Acosmium panamense</i> [billywebb]	<i>Cordia</i> sp. [siricote]	<i>Lacmellea</i> sp. [chicle dwarf]	<i>Sabal</i> sp. [botan]
<i>Albizia</i> sp. [wild tamarind]	<i>Cornutia pyramidata</i> [zopilote]	cf. <i>Leucaena</i> sp. [wild tamarind]	<i>Salix</i> cf. <i>humboldtiana</i> [willow]
<i>Allophylus</i> sp. [chal-chal]	<i>Coussapoa</i> sp. [matapalo]	cf. <i>Licania arborea</i> [succotz]	<i>Schefflera morototoni</i> [mountain trumpet]
<i>Alseis</i> sp. [mamecillo]	<i>Cryosophila stauracantha</i> [escoba palm]	<i>Licaria campechiana</i> [laurelillo]	<i>Schizolobium parathyba</i> [plumajillo]
<i>Alvaradoa</i> spp. [cortacuero]	<i>Cupania</i> spp. [grande betty]	<i>Lonchocarpus castilloi</i> [dogwood]	<i>Sebastiania</i> sp. [poison wood]
<i>Ampelocera bottlei</i> [bullhoof]	<i>Curatella americana</i> [sandpaper tree]	<i>Lysiloma</i> sp. [tsolam]	<i>Sideroxylon</i> sp. [silion]
<i>Andira inermis</i> [cabbage bark]	<i>Dalbergia stevensonii</i> [rosewood]	<i>Manilkara zapota</i> [sapodilla]	<i>Simira</i> sp. [chakte kok]
<i>Aspidosperma</i> spp. [malady]	<i>Davilla kunthii</i> [chumico]	<i>Matayba</i> sp. [white copal]	<i>Simarouba amara</i> [dysentery bark]
<i>Astronium graveolens</i> [glassywood]	<i>Desmodium</i> sp. [beggar's lice]	<i>Melicoccus oliviformis</i> [kinep]	<i>Suietenia macrophylla</i> [mahogany]
<i>Attalea cohune</i> [cohune]	<i>Diospyros</i> sp.	<i>Melochia</i> sp. [escobilla]	<i>Symphonia globulifera</i> [chewstick]
<i>Bauhinia purpurea</i> [palo de orquideas]	<i>Drypetes</i> sp. [bullhoof]	<i>Metopium brownei</i> [poisonwood]	<i>Tabebuia</i> sp. [yellow mayflower]
<i>Bignonia diversifolia</i> [alambre]	<i>Elbretia tinifolia</i> [bastard cherry]	<i>Micropholis</i> sp. [cafetos]	<i>Tabernaemontana</i> sp. [milkwood]
<i>Brosimum alicastrum</i> [ramón]	<i>Enterolobium cyclocarpum</i> [guanacaste]	<i>Mimosa</i> sp. [sensitive plant]	<i>Tapira mexicana</i> [tanto]
<i>Bucida buceras</i> [bullet tree]	<i>Eugenia</i> spp. [guabillo]	<i>Morinda</i> sp. [noni]	<i>Trichilia</i> spp. [red cedar]
<i>Bursera</i> spp. [gumbolimbo]	<i>Exostema</i> sp. [princewood]	<i>Nectandra globosa</i> [timber sweet]	<i>Trophis racemosa</i> [white ramón]
<i>Caesalpinia</i> sp. [warree wood]	<i>Exothea paniculata</i> [inkwood]	<i>Ocotea puberula</i> [wakkowit]	<i>Vitex</i> [blue blossom]

Table 14.1 (continued)

Trees [common name]	Trees (cont.) [common name]	Trees (cont.) [common name]	Trees (cont.) [common name]
<i>Calycophyllum candidissimum</i> [madroño]	<i>Ficus</i> sp. [fig]	<i>Oreopanax</i> sp. [aralia blanca]	<i>Zanthoxylum caribaeum</i> [prickly yellow]
<i>Cameraria latifolia</i> [poison wood]	<i>Garcinia intermedia</i> [jocomico]	<i>Pachira aquatica</i> [provision tree]	<i>Zuelania guidonia</i> [tamai]
<i>Carapa guianensis</i> [andiroba]	<i>Genipa americana</i> [huito]	<i>Pimenta dioica</i> [allspice]	
<i>Casearia</i> sp. [café de monte]	<i>Geonoma</i> sp. [surtuba palm]	<i>Pinus</i> spp. [pine]	
<i>Cassia</i> sp. [cañafistula]	<i>Grias cauliflora</i> [bombowood]	<i>Piscidia piscipula</i> [dogwood]	
<i>Cecropia peltata</i> [trumpet tree]	<i>Guarea</i> spp.[cedrillo]	<i>Pisonia</i> sp. [uña de gato]	
<i>Cedrela odorata</i> [Spanish cedar]	<i>Guazuma ulmifolia</i> [wild bay cedar]	<i>Pithecellobium</i> sp. [turtlebone]	
<i>Ceiba pentandra</i> [ceiba]	cf. <i>Guettarda combsii</i> [arepa]	<i>Platymiscium</i> sp. [macacauba]	
<i>Celtis iguanaea</i> [hackberry]	<i>Haematoxylum campechianum</i> [logwood]	<i>Protium copal</i> [copal]	
<i>Chrysophyllum</i> sp. [star apple]	<i>Heliocarpus</i> sp. [broadleaf moho]	<i>Pseudolmedia</i> spp. [cherry]	
<i>Cissampelos pareira</i> [peteltun]	<i>Heteropterys</i> sp.[redwing]	<i>Psychotria</i> sp. [night bloom]	
<i>Clusia</i> sp. [matapalo]	<i>Hymenaea courbaril</i> [guapinol]	<i>Pterocarpus</i> sp. [bloodwood]	
<i>Coccoloba</i> sp. [papaturo]	<i>Inga</i> sp. [bribri]	<i>Quercus</i> sp. [oak]	

the tropics, let alone the neotropics (Wheatley 1969: 8); another is that intensification of “greenspace” is almost universally excluded as a developmental factor in the process of urbanization (Graham 1999: 191).

Many Maya cities were located at ecotones, that is, the intersection of two or more environmental zones which allowed residents to exploit a wide range of environmental opportunities. Tikal, for example, is located on a series of limestone ridges, pockmarked with small depressions and abutting a sprawling, complex wetland known today as the Bajo de Santa Fe. Evidence suggests that by sometime in the Classic period, sloping uplands in the urban zone were probably largely protected under a managed tree canopy to stabilize soils that had been greatly degraded during the Preclassic (Dunning et al. 2015; Lentz et al. 2014a). Maize and root crops were intensively cultivated chiefly in numerous small depressions or “pocket bajos” throughout the uplands, and along the margins of the Bajo de Santa Fe (Balzotti et al. 2013; Burnett et al. 2012; Dunning et al. 2015). Ironically, soil erosion and redeposition during the Preclassic had led to the creation of wide aprons of deep, highly cultivable soils along the flanks of bajos that formed some of the most valuable farm land in the Classic.

Land use in the Classic period had also to provide for the timber and fuel needs of the ancient populace. At Tikal, as much as 47% of the land within the city’s sustaining area would likely have had to remain under forest cover for the population’s long-term wood needs to have been met (Lentz et al. 2014a, 2015). Demand for wood included timber for construction and fuel to make lime plaster and to fire ceramics, but overwhelmingly, wood was needed to stoke thousands of cooking fires. Indeed over 88% of wood probably went into cooking fires (for a Late Classic population of 45,000 persons at Tikal, about 38 million kilograms of wood was needed per year to fuel household cook fires alone). Tikal’s forest resources also likely included specialized groves and reserves of prime woodlands. For example, sapote (*Manilkara zapota*), a tree selected for lintels in monumental architecture, was likely carefully managed in reserved woodlots to keep mature trees available (Lentz and Hockaday 2009; Ross 2011). Pine, a favored wood because of its fragrant smoke, was managed in groves within the Bajo de Santa Fe (Dunning et al. 2015) and was also naturally abundant in savannas (Beard 1953; Johnson and Chaffey 1974). Charcoal recovered from many other Maya sites indicates that pine may have become intentionally cultivated in areas outside its natural range because it was favored in ritual contexts (Lentz et al. 2005; Morehart et al. 2005). At least some cacao was grown in the city as well, likely in protected orchards, controlled by royalty or other elites (Lentz et al. 2014b, 2015). Notably, natural limestone sinkholes (*rejolladas*) containing the deep, moist soils and shady conditions favored by cacao were owned by privileged members of ancient Maya society as far north as Chichen Itza (Gomez-Pompa et al. 1987; Munro-Stasiuk et al. 2014). In sum, numerous studies indicate that Tikal and most Maya sites were surrounded by a mosaic of fields and forest, some fairly mature, some secondary scrub;

however, the specific composition of this field/forest mix likely varied greatly across space and time.

The varied environment of the Maya Lowlands included areas that presented few challenges and special challenges for urbanization. Blue Creek, Belize was the center of many small to medium-size cities spanning an ecotone, the last major escarpment abutting the coastal plain and the confluence of three rivers. The Blue Creek area had plenty of high rainfall and both a wide diversity of wetland and upland farming systems (Beach et al. 2015a, 2015c). In contrast, Chunchucmil was a large Maya city of the Early Classic period that thrived in an area of about half of Blue Creek's rainfall and less of its soil resource. Chunchucmil is also located along an ecotone, between the northwest karst plain and a series of coastal wetlands (Beach 1998). The city provides the quintessential low density urbanism (Isendahl 2012) example with two odd features: areas walled off to protect something and a remarkable lack of soil cover. Thick Boxlu'um soils (Calciustolls, Paleustolls, and Haplustolls) here formed in plaster and debris from the ancient city, but the main remnants are thin, red Kancab soils (Paleustalfs, Paleustolls, and Haplustalfs) with many limestone pavements (Figure 14.3) (Beach 1998). If they were growing something, then part of the soils along with the evidence for crops eroded into karst cavities and/or organic soils imported from nearby wetlands that were decomposed after input abandonment in the early part of the Late Classic (Beach et al. 2015b). Nevertheless, the city's residents probably also relied on imported foodstuffs from the coast and areas further inland where productive capacity was higher, a system that was made possible by Chunchucmil's vigorous trade economy (Dahlin et al. 2005). In short, Chunchucmil was a large trading port that was located as close to the coast as it could be given the lack of food production options along the coast and associated marshlands.

Another example of a Classic period city supported by a specialized agricultural system is Caracol, Belize. The city grew amidst a system of tens of square kilometers of terracing and many reservoirs in an extremely hilly landscape that would otherwise not have allowed such a large urban population concentration (Chase et al. 2011). The large scale and careful orchestration of this urban agricultural system imply a sophisticated level of organization, though it is unclear whether it relied on a centralized structure or a complex network of neighborhood overlords (Chase and Chase 1998; Chase et al. 2011).

Terrace systems with evidence for intensification are widespread around many Maya sites such as areas in northwestern Belize, the Petexbatun of Guatemala (around the site of Tamarindito), the Rio Bec, and the broader area such as the Vaca Plateau around Caracol and the upper Belize River Valley (Beach et al. 2002, 2011, 2015b; Dunning et al. 1998b; Lemonnier and Vannière 2013; Wyatt 2012). In most of these regions, terracing shows little evidence of centralized or formal organization. Rather, the terrace systems seem to have grown accretionally over many generations in both urban



Figure 14.3 Photo by T. Beach (July 2006) of typical Chunchucmil, Mexico soil and surface, showing the thin, red Kancab soils and preponderance of limestone surfaces.

and rural settings. Nevertheless, the terraces often show considerable sophistication, displaying multiple forms adapted to specific topographic contexts including footslope, midslope, and drainage way settings (Figure 14.4). In many regions, terraces are spatially associated with rural (and sometimes urban) farmsteads: clusters of residences tied to agricultural land (Dunning 2004). In many cases, the relationship between terraces and residences is made explicit by the presence of linking or bounding field wall (Figure 14.5).

A conurbation centered on the ancient site of Dzibanche is an example of urban growth in a wetland setting: an isthmus of higher terrain separating two large bajos in southern Quintana Roo, Mexico (Dunning and Beach 2010). Aerial surveys indicate that as much as 240 square kilometers of

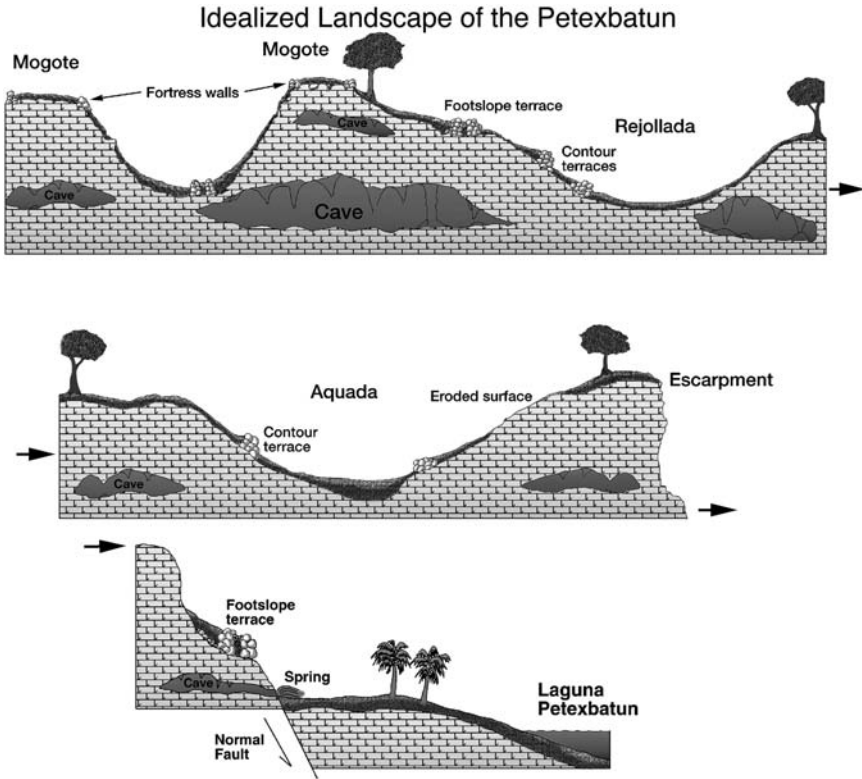


Figure 14.4 Idealized diagram of the Petexbatun landscape in Guatemala showing the complex interplay of terraces, defensive walls, and karst features. (Created by T. Beach).

these swamps were converted into a complex system of wetland fields and canals. The urban nodes of Dzibanche and residential areas spread along areas of higher ground, some linked by causeways. Although the wetland field system has not been dated, the urban site began to grow in the Late Preclassic and reached its peak towards the end of the Early Classic, and the agricultural system is presumably coeval.

Wetlands field systems are also found in areas far removed from major urban centers indicating that this adaptation was important in the ancient rural economy (e.g. Fedick and Morrison 2004; Luzzadder-Beach et al. 2012). Field systems exhibit a wide array of forms ranging from regimented, rectangular examples (as at BOP in Figure 14.6b) to organic shapes fit into wetland niches (as at Chan Cahal in Figure 14.6a). This formal diversity suggests variation in organizational impetus in their creation and management.



Figure 14.5 Photo by N. Dunning (April 1991) of a field wall and agricultural terraces in the Petexbatun region of Guatemala. The field wall in the right foreground is running downslope into a *rejollada*, demarcating a parcel of terraced land to the left.



(a)



(b)

Figure 14.6 Photos by S. Luzzadder-Beach of a) Chan Cahal Fields; b) Birds of Paradise (BOP) fields in northwestern Belize.

Environmental change, adaptation, and abandonment

As inventive and well adapted as the ancient Maya agricultural system became in the Classic period, it also had weaknesses. Across most of the Maya Lowlands, the success of agriculture was dependent on the reliability of rainfall. Annual rainfall in the Maya Lowlands is highly seasonal with a pronounced dry season from December to May, and agriculture must be

timed to its rhythms. Drought over a number of years has been the bane of Maya farmers for millennia. In the Maya case, “drought” does not mean *no* rainfall but instead lower overall precipitation over a number of dry and rainy seasons, and perhaps more unpredictable onset. Most Maya agriculture was utterly rainfall dependent, and many interior communities were completely dependent on the collection and storage of rain water to remain occupied year-round. Hence, even moderate disruptions in the expected pattern of rainfall could play havoc in ancient cities and countryside alike (Dunning et al. 2012). Mounting paleoenvironmental data indicate that periods of particularly severe droughts may have afflicted wide areas of the Maya Lowlands in the 4th century BC, and the 2nd, 9th, 11th, and 16th centuries AD (e.g., Douglas et al. 2015; Dunning et al. 2014; Haug et al. 2003; Hodell et al. 2005; Kennett et al. 2012; Medina-Elizade et al. 2010; Medina-Elizade and Rohling 2012; Wahl et al. 2014). These were temporally concentrated series of droughts, enough to devastate crop production, as well as forest resources. Notably, the steady decrease of forest cover that occurred across the Maya world as population expanded in the Late Preclassic and again in the Late Classic may have significantly exacerbated drought severity (Cook et al. 2012; Griffin et al. 2014). Droughts in the 2nd and 9th centuries AD have received the most attention because these are coincident with substantial demographic rearrangements across wide areas, although not all regions were affected as severely (Graham 2004; Pendergast 1986, 1990). Drought posed the greatest problems in the Elevated Interior Region (EIR), where natural perennial water sources are especially scarce and rain water had to be collected and stored to permit year-round occupation (Dunning et al. 2012; Scarborough et al. 2012). While droughts likely contributed to the decline of Maya civilization during these times, other problems were evident as well, including declining soil fertility, over population, and a political system that was poorly suited to dealing with such crises (Aimers and Hodell 2011; Iannone 2014; Yeager and Hodell 2009).

Human-environment interactions are often highly intertwined, and modeling these interactions requires a complex systems perspective. A good example of the complexity of such interrelationships can be illustrated by the effects of forest removal in the Maya Lowlands (Dunning et al. 2012; Turner and Sabloff 2012), a cascade of interactions that begins with the nature of bedrock on the Yucatan Peninsula. Much of this limestone bedrock is nearly pure calcite. In the southern Lowlands, a large part of the inorganic fraction of soils has derived from windblown volcanic ash, which blends northward with Saharan and North American eolian dust and the bedrock constituents. While these soils are fairly fertile, they are notoriously low in phosphorus. Over the long term, phosphorus is recharged by new inputs of volcanic ash. On an annual basis, phosphorus is recharged by inputs of eolian dust (Das et al. 2011; Lawrence et al. 2007). However, as forest is progressively removed from a location, the capture of dust is proportionally diminished leading to decreasing phosphorus levels in the soil.

Thus, as agriculture was intensified across the Maya Lowlands, phosphorous levels in regional soils would have progressively declined. Reductions in forest fallowing would also likely decrease nitrogen levels by reducing inputs from leguminous species, e.g., *Leucaena* spp., *Lonchocarpus* spp., *Acacia* spp., etc., which comprise a significant portion of regional forests. Declining soil fertility would have had cascading effects. Crop yields would have decreased necessitating opening more land for farming and clearing more forest, if any forest remained. Plant health would have suffered, making crops more vulnerable to diseases such as maize mosaic virus. Declining soil fertility would also increase vulnerability to field invasion by weedy species, most notably of bracken fern (*Pteridium aquilinum* spp.), an aggressive plant that thrives in nutrient-poor soil and which is noted for invading over-cropped fields in the Southern Maya Lowlands and for being difficult to remove once established (Dunning and Beach 2010; Pérez-Salicrup 2004). Thus, ironically, while the high-base-status soils and tropical climate of the Maya Lowlands were favorable for cultivating maize and supporting high population densities, population growth led to the incremental reduction of forest for construction material, fuel, and farm land which would have created a risk spiral within the region, especially when coupled with other environmental and cultural risk factors (Dunning et al. 2012; Turner and Sabloff 2012).

Postclassic decline and revival

After periods of population change, Maya cultivation practices tended to revert to longer fallow *milpa* systems. However, more intensive systems did not disappear. For example, wetland cultivation was apparently an important part of the Postclassic economy in the Rio Candelaria and Bahia de Terminos regions. Evidence for Postclassic use of the wetland fields continued in Belize as suggested by both colonial documents (Jones 1982) and wetland field excavations. However, the excavations indicate extensive use rather than intensive wetland management (Beach 2015a; Luzzadder-Beach et al. 2012).

Today, where traditional Maya agricultural practices prevail, the ancient rhythms continue to be observed. The cutting and burning of forest, planting of maize, beans, and squash, and harvest are all timed to the coming and going of the rains. But nothing is assumed. Supplication is still made to ancient deities or saints at the necessary times. The rains come. Maize grows. Life continues.

Discussion

Maize. Manioc. Mamey. Indeed all three of these foodstuffs—and many more—played essential roles in how the ancient Maya fed themselves. In small villages such as Ceren, the Maya devised a system of agricultural production that included intensive cultivation of maize, root crops, beans, vegetables, and fruit trees in close proximity to their residences, as well as larger

fields of staples such as maize and manioc at greater distances. This pattern of diverse cultivation was extended to progressively larger towns and cities over time, albeit with differences in intensification strategies adapted to varied environmental settings and different political economic situations. Given the example of Chunchucmil, a pattern of trade and markets seems also to be emerging, which challenges the archaeological notion of Maya self-sufficiency. But we will need more regional subsistence studies to judge the significance of this challenge.

While the Maya successfully adapted many long-term strategies to survive and thrive in their complex tropical environment, their occupation also generated degradation, some of which they were able to overcome, but some of which compromised sustainability. An important aspect of coming to understand ancient human-environment systems is that such knowledge can help not only in assessing the successes and failures of past societies, but also informing predictions of sustainability and resilience of similar systems and their components in the future (Fisher et al. 2009). The perspective of using information gathered from archaeological investigations of all kinds, especially those that most directly involve humans and the environment, underlies a growing body of research (for example, approaches on the systems scale such as that supported by the IHOPE initiative (Chase and Scarborough 2014; Costanza et al. 2007), and smaller scale socio-ecological approaches (Graham et al. 2017)). Ultimately, what we can learn about the capacity to adapt to environmental change, including that induced by human activities, may be the most enduring product of our studies of the ancient world.

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15 Getting to the grain

The domestication of *Zea mays* in Mesoamerica and beyond

Robert P. Kruger

Introduction

Of the Great Grains that have been domesticated around the world – wheat, barley, rice, millet – maize (*Zea mays*, or “corn” as it is known in much of the English-speaking world) is almost certainly the most successful. Today it is widely cultivated in every continent and region of the world, with the exception of the polar regions. Because of its extraordinary adaptive capacities, varieties of maize have modified to survive and even thrive in very different conditions, from very hot topical conditions to the short growing seasons of the far north and south; and from very arid to very humid conditions. No other major domesticated plant has shown such capacity for adaptation. As a result, world maize (corn) production today is greater than any other domesticated grain (USDA (United States Department of Agriculture) 2016).

The phenomenal success of modern maize is built upon the foundations laid down by thousands of years of pre-historic cultivators and farmers in the cultural region known as Mesoamerica (Figure 15.1). Maize, together with beans (*Phaseolus* sp.) and squash (*Cucurbita* sp.) – collectively known as “The Three Sisters” for their complimentary nature both in the traditional agricultural fields and in their contributions to human nutrition – fueled the development of the great kingdoms and empires of Mesoamerica – the Maya and Aztec, Zapotec and Tarascans (or Purépecha) (Bonfil-Batalla 1982: 53; Coe and Koontz 2013: 10; Fash and Lyons 2005: 15; Matos-Moctezuma 2013; Neiderberger 1996; Sanders and Price 1968: 9). Each of these cultures found their own ways of venerating maize, with specific gods, rituals, and stories demonstrating the fundamental role that the plant played in their societies (Bonfil Batalla 1982: 25–30; Coe 1962; Joralemon 1971; Pérez-Suárez 1997; Taube 1995, 2000). Even today a special respect for the maize plant exists in Mexico. It is common to see a single maize plant growing out of an otherwise well-manicured garden or public space: you simply do not cut down the maize!

Maize also reached well beyond the confines of Mesoamerica. Well before the arrival of the first Europeans it was being cultivated from Nova Scotia



Figure 15.1 Map of Mesoamerica with regions mentioned in the text. (Created by author).

in Canada to the southern reaches of South America, as well as into the Caribbean (Blake 2015; Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez 2011, 2013; Pagán Jiménez et al. 2015; Piperno and Pearsall 1998; Smith 1995). Though present throughout these regions, however, its use and importance varied widely. Maize eventually became the dominant cultivar in what is now the southwestern United States as well as eastern North America. In the Caribbean, the archaeological evidence suggests that maize entered in the region as early as 5790 BC (Pagán Jiménez et al. 2015), eventually becoming a common cultivar, at least by 350 BC (Mickleburgh and Pagán Jiménez 2012), although root cultivars such as zamia (*Zamia* sp.), manioc (cassava) (*Manihot esculenta*), and sweet potato (*Ipomoea batatas*) were probably as equally important to early Caribbean precolonials (Keegan and Carlson 2008; Mickleburgh and Pagán Jiménez 2012; Pagán Jiménez 2011, 2013; Piperno and Pearsall 1998; Rouse 1992; Wilson 2007). The early arrival of this plant throughout most of the Americas speaks to its attractiveness and usefulness to these societies.

Domesticating maize: out of the wild

The origins and processes of development of this important crop have been major areas of investigation for much of the second half of the twentieth century, and these investigations still continue today. The great champion of this story is of course Richard “Scotty” MacNeish, who for many years searched for the origins and ancestor of maize as part of a larger study of Archaic Age (approximately 9000–2000 BC) cultural ecology in central

Mexico (Coe and Koontz 2013: 26–36; García-Cook 1997). Though he worked in many parts of Mesoamerica, his most important contributions came in his multi-year and multi-disciplinary study of the semi-arid Tehuacan Valley of Puebla State, Mexico (Figure 15.1) (Mangelsdorf et al. 1967). From his excavations at many sites within the valley, including importantly the dry caves of El Riego, San Marcos, and Coxcatlán, MacNeish was able to reconstruct much of the ancient lifeways of the inhabitants of the region from approximately 10,000 years ago through to historic times. Central to his investigations, especially in his study of the Archaic occupations of the valley, was his effort to discover the origins and ancestor of *Zea mays*. Supported by the influential botanist Paul Mangelsdorf, MacNeish became convinced that domesticated maize came from a now-extinct wild version of the same plant which they posited would have had a small central cob structure supporting its seeds, as modern maize does (Mangelsdorf 1974; Mangelsdorf et al. 1964, 1967). MacNeish and his colleagues were able to excavate some very early cobs that corresponded to what they thought fit their idea of what wild (undomesticated) maize would look like. Originally estimated to date to around 4280 BC, these specimens have recently been directly dated using Accelerator Mass Spectrometry to around 3540 BC, and are now known to be a variety of already domesticated maize (Smith 2005). Somewhat earlier specimens of domesticated maize have been recovered from the cave of Guilá Naquitz in the Valley of Oaxaca by Kent Flannery, with dates of around 4250 BC (Flannery 1986).

It was not until early in this century that genetic evidence demonstrated conclusively that the ancestor of maize was not an extinct wild maize but rather a type of wild grass that still grows in the highlands of southern Mexico, known as *teosinte* (sometimes spelled *teocinte* or *teocintle*) (Doebley 2004; Matsuoka et al. 2002). Teosinte is the popular local name given to several sub-species of wild grasses that grow among the semi-arid hills of the southern mountains of Mexico. There are both annual and perennial varieties, and while from a distance they appear similar to the maize plant, close at hand they have several marked and important differences. Whereas maize generally grows a single thick vertical stalk, teosinte grows a multitude of thinner stalks from the base (perhaps as many as a dozen or more), and some of these stalks may branch out even more as they grow.

More strikingly different from domesticated maize, which generally will produce only one or two cobs per plant, wild teosinte has multiple loci of seed production. Each branch may produce eight or more loci of seed production, and each of these loci will generally have multiple small spikes with eight to twelve seeds arranged along it, each spike wrapped in its own protective leaf or sheath (Figure 15.2). Therefore any given teosinte plant may have a hundred or more different loci of seed production, each maturing at different times. It is important to note that teosinte has no central cob structure as domesticated maize does, but rather a very narrow spike that seeds are attached to in an alternating pattern. Once mature, these seed spikes and



Figure 15.2 A green teosinte (*Zea mays* ssp. *parviglumis*) seed spike with the protective sheaf of leaves removed. (Photo by author).

surrounding leafy sheaves become very brittle, allowing the plant to easily disperse its seeds. These characteristics would make it very difficult and tiresome for human populations to efficiently harvest the seeds, since mature seeds could be in various different parts of the plant, and only a small percentage of the seeds would be mature at any one time – though harvesting green, immature seed spikes would be somewhat easier (Flannery 1973).

Moreover, teosinte seeds themselves are small and triangular shaped, measuring only 4–7 mm on a side. When mature they are covered in a thick, hard shell or glume that protects the seed itself from predators and from premature sprouting, which makes it very difficult to get to the tiny fleshy nutritional part of the seed inside. In domesticated maize, this glume has become very reduced or has disappeared completely, leaving the much larger fleshy kernels exposed. The type of teosinte most closely related genetically

to domesticated maize is from the area around the Río Balsas region of the state of Guerrero, *Zea mays* ssp. *parviglumis* (Figure 15.1) (Doebley 2004; Eubanks 2001; Matsuoka et al. 2002). As the name implies, it is currently considered to belong to the same species as domesticated maize – teosinte and maize can and do cross-pollinate (Eubanks 2001).

Because of the small size and inaccessibility of the edible parts of their seeds, plus the difficulties presenting in harvesting them, teosinte seeds would seem to be an unlikely focus of attention for Archaic Age foragers, and even less likely to be subject to selection and manipulation by those foragers. Nevertheless, it appears that teosinte was coming under selective pressures very early on during the Archaic Age (Blake 2015). There is some microbotanical evidence that early domesticated maize existed in the Río Balsas valley by around 6700 BC (Piperno et al. 2009; Ranere et al. 2009). Moreover, it seems that either teosinte or a newly domesticated maize plant was brought out of its natural area and was being cultivated in very different ecological zones than its semi-arid upland homeland within a millennium or so of this date. Pollen, phytolith, and starch grain analyses have provided data that suggest that teosinte or early domesticated maize was being cultivated in humid lowland settings, and at great distances, fairly early on. Phytolith and pollen of maize show up in small quantities in deposits dated to approximately 5200 BC from the wet riverine site of San Andrés, Tabasco, very near the Gulf Coast (Pohl et al. 2007; Pope et al. 2001). Slightly earlier micro-botanical evidence may have been found in Panama, with dates as early as 5500 BC (Dickau 2010; Dickau et al. 2007), along the Northern South America–Southern Caribbean interface around 5800 BC (Pagán Jiménez et al. 2015) and lowland Ecuador, at around 5400 BC (Piperno and Pearsall 1998).

It is worthwhile here to note the major differences that occurred in the long domestication process that transformed teosinte into the maize that was so important to pre-Columbian Mesoamerican civilizations and to our modern world today. The most marked and significant long-term transformation of the plant has been its phenomenal increase in the production of edible seeds as well as their relative ease of harvesting and processing. From a plant that produced many small barely edible seeds dispersed along multiple stalks, selection processes over millennia have produced a highly productive organism that concentrates hundreds of nutritious seeds into one or two large “packets” or cobs on a single stalk. This is to be expected, and occurs in many domesticated comestible species: many generations of selection result in a significant increase in the overall production of product – in this case, kernels of high-carbohydrate maize. Unfortunately, no early transitional teosinte-to-maize macro-remains have been archaeologically recovered to date, so we cannot comment directly on the beginning stages of this transition. The recovery of early cobs in the valleys of Tehuacan and Oaxaca around 5000–4000 BC tells us that the transition to a cob as a central structure for producing the seeds or kernels was a fairly early transformation (Flannery 1986;

see also Kirkby 1973). Nevertheless, it is important to note that these early cobs were quite small and only carried a limited number of kernels, perhaps a few dozen – nothing like the long ears of maize with hundreds of seeds that now come out of the farms of Illinois and Kansas.

It is also likely that the elimination of all but a single central stalk to support the cob(s) of maize kernels was an early transformation of domesticated maize – in part at least because it is a common feature of all known domesticated *Zea* throughout the Americas (Blake 2015). Had it been a later modification, one would expect to find some far-off regional variants with multiple stalks, which is not the case.

However, these two *early* modifications in the early teosinte-to-maize transformation (reduction of the number of stalks and the reduction of seed-producing loci to one or a few cob structures) seem counterintuitive to what we would expect, and put us into something of a quandary. If early selective pressure of teosinte and early maize was toward *increasing kernel production* (and therefore increased carbohydrate production), as we see happening in the long term with *Zea mays*, then why do we see an initial *massive decrease* in the number of seed producing loci – and therefore a major decrease in seed production? Given the small size of the circa 5000 BC cob from Oaxaca, it would seem that the result of the first several thousands of years of selective pressures may have been a *reduction* rather than an increase in the overall production of carbohydrate-bearing material per plant.

This brings us back to a point made earlier: why would early foragers decide to cultivate and manipulate the teosinte plant and its unlikely, unattractive, and unproductive seeds in the first place, and why did it spread so far so quickly? We certainly cannot bestow upon the foragers of the Archaic Age the gift of foreseeing the massively productive cultigen the distant descendants of teosinte would become many millennia later. The hard, tiny, barely digestible seeds of the teosinte plant would have had little to recommend them at the time. Nevertheless, there must have been something about the plant that was immediately attractive to the inhabitants of the central reaches of the Río Balsas some 8,000 to 10,000 years ago. Why was it so attractive to communities outside its natal zone that it, and no other plant, was transferred all the way along the lowlands southward to central Pacific Coast South America in a matter of centuries?

A very plausible solution to this conundrum came in 2003 when John Smalley and Michael Blake published an article in *Current Anthropology* called “Sweet Beginnings: Stalk Sugar and the Domestication of Maize” (Smalley and Blake 2003). In this article, the authors propose that early foragers were *not* interested in the seeds of the teosinte plant, but rather in the sweet juices of the maturing stalk. They point out that while humans naturally crave sweet, there were relatively few sources of that sensation in the forager’s diet at the time. One exception was the juices of some types of grasses growing in the mountains of central and southern Mexico. Just as sugar cane (a domesticate of Southeast Asia) concentrates large amounts of

sugar in its stalks, some larger grasses in the southern Mexican highlands produce sugars in their stalks that are then transformed into the carbohydrates of the seeds as they grow and mature. Smalley and Blake build on earlier investigators' observations of this phenomenon (Iltis 2000) to make a case for stalk sugar, not starchy seeds, as the central focus of attention of Archaic Age foragers.

This hypothesis goes a long way in explaining many of the troubling aspects of the early domestication and translocation of *Zea* across Mesoamerica and beyond. Whereas the hard innutritious seeds of the teosinte plant would probably not have been attractive either inside or outside its native zone, a ready source of sweetness in the stalk sap would likely have been a welcome addition to many local diets. It therefore may have been transported along the length of the Americas in a "down-the-line" fashion, with communities sharing it or trading it with their neighbors until after many generations and exchanges it was adopted by the far-off communities of coastal central South America and the Caribbean. Once it was taken from its native zone, it may well have been considered an exotic and attractive commodity, receiving much attention.

Similarly, the seeming problem of a reduction in early seed production (through the reduction of both the number of stalks and number of seed-producing loci on the remaining stalk) would make sense if early selective pressure was placed on enhancing the production of stalk sugars. First, the elimination of all but a single stalk, and the increase of size of that stalk, would reduce the amount of harder structural fibers needed to support and hold up the plant, and a thicker central stalk would provide more interior space for the production of softer sugary tissues. Moreover, a reduction in the number of seeds being produced may also have led to more concentration of sugars in the stalk, since less of that sugar would be transformed into carbohydrates in the seeds (Smalley and Blake 2003: 679).

This sugar-before-seeds hypothesis of maize domestication would mean that during the first millennia of cultivation, maize was not used so much as an important source of nutrition, but rather as a special commodity, an enhancement or supplement to the foragers' diet. Smalley and Blake go so far as to argue that the juice from the maize stalk was likely fermented in some cases, producing an alcoholic beverage that could have been very attractive to Archaic Age foragers and may have played an important role in rituals and ceremonies. Such a maize stalk beer, ethnographically called *tesgüino*, has been frequently recorded both historically and ethnographically in various parts of Mexico (Smalley and Blake 2003: 680–681). Beverages, fermented and otherwise, can also be produced from the carbohydrate-rich kernels. Clark and Blake (1994) have proposed that the use of such fermented beverages in competitive feasting in early Mesoamerica may even have led to early forms of sociopolitical complexity in the Soconuzco region of coastal Chiapas.

At some point, there was a shift in focus in the maize plant, and the maize seed or kernel became a central point of attention. Indeed, it is clear that

there were important modifications to the seed-producing mechanisms of the plant very early on (Blake 2015: 104–114), and a definable kernel-bearing cob was present archaeologically by the fifth millennium BC at the very latest. Nevertheless, the cob was small, with relatively few seeds, and this continued to be the case for the following millennia as well (Flannery 1986; Kirkby 1973). This small cob size and kernel yield mean that the potential for carbohydrate-based food production was still very limited, even relatively late in human prehistory in Mesoamerica, perhaps well into the Formative Period in some areas.

Maize among the Gulf Coast Olmec

Archaeological evidence suggests that maize may have had something of a divergent history between upland and lowland areas of Mesoamerica. Archaeological evidence in both artifact assemblages such as grinding stones (known as *manos* and *metates*) and quantities of maize recovered suggest that the carbohydrates of maize kernels were becoming an important part of the human diet by the Early Formative Period (beginning around 1600 BC) in several areas of highland Mexico (Byers 1967; Flannery 1976, 1986; MacNeish et al. 1967), and for a long time the same was assumed to be true for the lowland areas of Mesoamerica as well (Coe 1981; Coe and Diehl 1980; Diehl 1989: 25; VanDerwarker 2006: 36–37). However, for many years there was little direct evidence to support these assumptions, beyond the discovery of grinding stones in archaeological contexts and an appreciation for the great productivity of the soils in the area today (see VanDerwarker 2006: 37).

Nevertheless, beginning in the 1990s and increasingly in the 2000s, some authors began expressing skepticism about what was known (or assumed) about subsistence patterns in lowland and coastal areas of southern Mexico (Arnold 1999, 2000, 2009; Blake et al. 1992; Borstein 2001; VanDerwarker 2006). In the Olmec heartland of southern Veracruz and western Tabasco, Arnold (1999, 2000, 2009) and Borstein (2001) challenged notions of an Olmec subsistence strategy based on the cultivation of maize (see also Killion 2013). Though there was indirect microbotanical evidence for the presence – and therefore cultivation – of maize in the region for millennia prior to the rise of the Olmec (Pohl et al. 2007; Pope et al. 2001), the quantity and quality of that maize, or even if the main focus was for the carbohydrates of maize kernels, the sugary juice from its stalk, or both, remained unknown. Direct quantifiable data on Early Formative (1600–1000 BC) and Middle Formative (1000–400 BC) subsistence patterns remained lacking (but see Zurita-Noguera, 1997 for a preliminary study of phytoliths from the early Olmec capital of San Lorenzo).

In 2012, my colleague Amber VanDerwarker (a paleoethnobotanist with ample experience working with Gulf Coast materials) and I published an article describing the ethnobotanical material recovered using flotation techniques from a single-occupation rural homestead named San Carlos for the

local community nearby (VanDerwarker and Kruger 2012). San Carlos has been dated by AMS radiocarbon assay (GX#25529-AMS) to approximately 1130 BC (calibrated) – although the ceramic assemblage may indicate a slightly later date for the occupation, at the Early to Middle Formative transition, around 1000 BC. The site is located a mere 9 km from the major Olmec sociopolitical center at that time, San Lorenzo, and was almost certainly part of the hinterland support area for that center in its later stages of power (Kruger 2000) (Figure 15.3). Moreover, we compared those findings with paleoethnobotanical data recently recovered from two other Olmec period sites: Tres Zapotes, an major Olmec center that gained prominence sometime during the Middle Formative which is located to just west of the foothills of the Tuxtla mountains (Pool 2000, 2003, 2010; Pool and Ortiz Ceballos 2008, Pool et al. 2010); and La Joya, a small semi-permanent village site in a valley of the Tuxtla Mountains, well away from any Olmec period political center (Arnold 1999, 2000, 2003). All three of these sites yielded at least some Olmec-style carved pottery, suggesting each was in some way tied into the overall Olmec social milieu, yet each represents very different aspects of life during the Formative Period in the Olmec Heartland. Tres Zapotes was a growing sociopolitical center during the Early Formative, and became an important regional power during the Middle Formative – one of the three

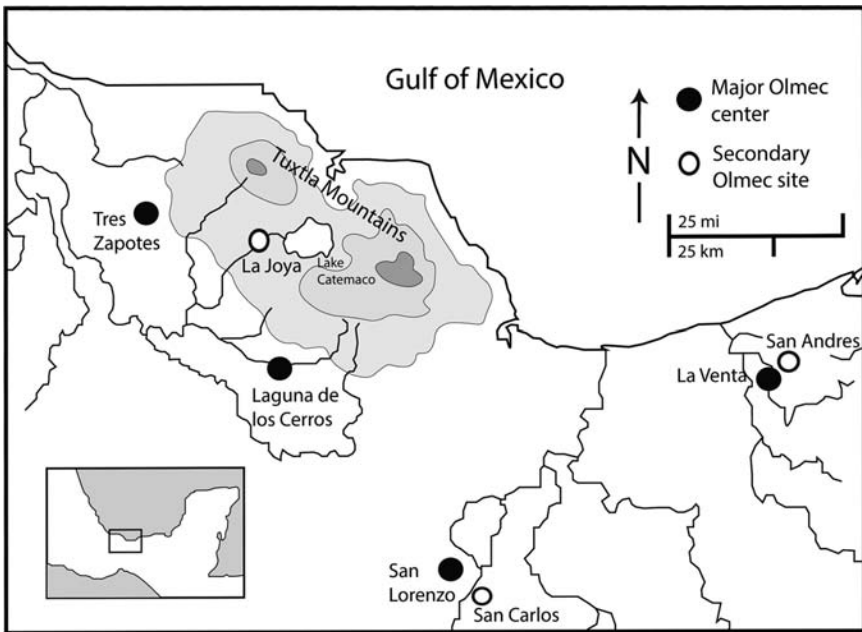


Figure 15.3 Map of the Olmec Heartland with the location of important sites. (Created by author).

important Olmec centers ever located. La Joya, in the Tuxtla Mountains, was the opposite – a small, perhaps semi-permanent village away from centers of power. San Carlos probably provided a support function for the Olmec center of San Lorenzo, just 9 km away. Both La Joya and Tres Zapotes yielded paleoethnobotanical data from both Early and Middle Formative contexts (Peres et al. 2010; VanDerwarker 2006), while the San Carlos data are confined to a single occupation at the Early to Middle Formative transition. This is the first, and to date the only, comparative study of macro paleoethnobotanical remains between Olmec period sites along the Gulf Coast.

A variety of plants, both domesticated and wild, were identified from these sites. Most importantly for our discussion, maize was located in each site. What is most interesting, however, are the different *patterns* in the presence of maize between these contemporaneous sites. Examining three different measurements to evaluate our observed patterns (Ubiquity, or the frequency with which maize appeared in the flotation samples for each site and time period; Density, or the frequency of maize per total volume of soil floated; and Mean Maize Counts, which is the average number of maize specimens recovered in those flotation samples that possessed any maize at all), a very striking pattern emerged (VanDerwarker and Kruger 2012). Both Early and Middle Formative Tres Zapotes, which was emerging as an important regional political center, had the highest values in each of these measures. The Early Formative flotations had an almost 100% Ubiquity of maize – meaning that almost every flotation had at least some maize in it. Maize Density and Mean Maize Counts confirmed that maize was very commonly found at this site through both the Early and Middle Formative occupations. The hinterland homestead site of San Carlos also showed fairly high values in each of these measurements, but never equaling Tres Zapotes. For example, San Carlos had a Ubiquity rating of 64.6, meaning that about 65% of the flotation samples from this site yielded at least some maize. Values of maize Density and Mean Counts confirmed that while maize was present, it was not nearly as common as it was at Tres Zapotes. Finally, at the remote semi-permanent village of La Joya in the Tuxtla Mountains, maize had a Ubiquity rating of only 22.8% in the Early Formative, and 32.4% in the Middle Formative. The other measurements again confirmed that maize had only a light presence at the site during both the Early and Middle Formative occupations when compared to the other two sites.

All of the analyses of the paleoethnobotanical data were performed by VanDerwarker, who was able to confirm that each site had similar conditions of preservation. Therefore, the differences noted cannot be explained by investigator bias or differential preservation. It is also unlikely that the differences are due to climatic conditions, since the three sites have similar environmental conditions: though La Joya is located in the Tuxtla Mountains, it is still only about 200 m asl, and has a very similar climatic regime to the other two sites. Therefore, we must look elsewhere to explain the very notable differences in the presence of maize in these three contemporaneous sites.

It is tempting to conclude that the larger political centers like Tres Zapotes were growing and consuming more maize in order to satisfy a larger population that was stressing the natural resources of the local ecosystem. However, to date there are no data to suggest that Tres Zapotes or its surrounding region supported a large population during the Early Formative Period (Loughlin 2012; Pool 2003; Pool and Ortiz Ceballos 2008; Pool et al. 2010). While there is evidence for higher population around San Lorenzo during the Early Formative (Symonds et al. 2002), the hinterland site of San Carlos showed only moderate presence of maize, not the intense production that one would expect if it were being grown on a grand scale for feeding a large population. Therefore, it is unlikely that maize cultivation was driven by hungry populations.

The strongest correlation of the different intensities of maize production and consumption at these three sites is with their proximity to or distance from centers of socio-political activities. The inhabitants of the rising center of Tres Zapotes were using maize quite frequently, suggesting that it was very important to activities at the site. The hinterland homestead of San Carlos, not far from another major political center, was producing and consuming a fair amount of maize, but not as much as at the main center. It is likely that at least some of the maize they produced ended up at San Lorenzo, but there was also some consumption of maize in this rural homestead, perhaps mimicking or adapting rituals they witnessed at the capital. Finally, the inhabitants of the isolated village of La Joya, far from the political maneuvering of the larger centers, utilized maize only lightly. It is therefore argued that during the Early and probably much of the Middle Formative Periods, maize was used as a supplemental product, likely within the context of rituals and ceremonies tied to sociopolitical activities, rather than primarily as an important food staple (VanDerwarker and Kruger 2012). As mentioned earlier in this chapter, maize stalk juice, as well as grains, can be fermented to produce alcoholic beverages, and it may have been these fermented beverages that were of such important to these ceremonies. A similar hypothesis has previously been proposed for the Early Formative cultures along the Pacific coast of Chiapas, and may well explain these patterns of maize consumption among the Olmec of the Gulf coast as well (Clark and Blake 1994). It is interesting to note, for example, that at San Carlos no grinding stones for the processing of maize grains were recovered from clear Early Formative contexts. This further suggests that rather than processing dried maize kernels, the inhabitants of this household were processing and consuming maize in other ways, perhaps as a beverage (fermented or otherwise) from maize in its green state.

Remarks and conclusions

Research into the origins and spread of maize has been long and full of surprises. Early investigators believed that the trajectory of maize was a straight

line from a primitive plant sharing the same general characteristics of modern maize that was selected and bred to produce ever greater yields of starchy grains that could fill the stomachs first of foragers, then horticulturalists, and finally full-fledged farmers (Mangelsdorf 1974; Mangelsdorf et al. 1964, 1967). Multiple lines of investigation have ultimately shown a much more complex and interesting history. It is now widely thought that earliest maize domestication from the wild teosinte grass was focused *not* on the starchy kernels but on the sugary stalks (Itlis 2000; Smalley and Blake 2003). Some of the early selective processes of this domestication may have actually had the initial effect of *reducing* the production of starchy kernels, since the numbers of seed producing loci per plant were greatly reduced while early domesticated maize cobs remained small. Like many other early Mesoamerican domesticates such as gourds and chiles, early maize may have been domesticated and dispersed early on throughout the Americas not as a staple food source, but rather as a supplement to enrich and provide variety to the existing local diets. If Smalley and Blake (2003) are correct, *Zea* stalks may have been first chewed, then squeezed or crushed to extract sweet juices, and these juices in some cases may have been purposefully fermented to produce mind-altering beverages. These beverages may have then taken on symbolic and perhaps even sacred properties within some societies (c.f. Clark and Blake 1994). Among the Gulf Coast Olmec, the pattern of early maize production and consumption also seems to support such a hypothesis (VanDerwarker and Kruger 2012).

It was only surprisingly late that the importance of maize seems to have shifted toward becoming a subsistence cultigen. Along the Gulf Coast of Mexico, several researchers suggest that the size of cobs and grains increased enough to make it economically worthwhile to produce it as such – what Borstein (2001) has called a Productive Threshold – sometime around 1000 BC (Arnold 2009; Borstein 2001), though recent evidence may push this date forward to perhaps as late as 500 BC (VanDerwarker and Kruger 2012).

However, it is also important to note that simple increases in the production of cob size and kernels would not be sufficient to establish a healthy functioning society based principally on maize kernels for its sustenance. Simple unprocessed maize is low in many proteins and several important amino acids – importantly, lysine and tryptophan, as well as some types of vitamin B, especially niacin, or vitamin B₃ (Blake 2015: 183–185; Katz et al. 1974). A diet based primarily on unprocessed maize would likely provoke serious nutritional problems, most importantly the vitamin-deficiency disease pellagra, as has been seen in several historic populations based mainly on maize consumption (Staller and Carrasco 2009: 317). Mesoamerican populations eventually solved this situation through the process of *nixtamalization*, whereby the maize is either soaked overnight or boiled in water containing ashes, lime, or some other type of alkali, which serves to break down and release these fundamental amino acids (Bonfil-Batalla 1982: 22; Katz et al. 1974; Staller and Carrasco 2009: 317). Without this

process for releasing these important nutrients a society based primarily on maize would suffer from important indices of malnutrition. Unfortunately, it is not easy to identify the process of nixtamalization in the archaeological record (see Blake 2015: 183–193), but there are some indications that it may not have become common in the Gulf Coast region until well into the Middle Formative, or perhaps even the Late Formative Periods (Killion 2013: 590).

Since this book is primarily focused on farming in the Caribbean, it may be appropriate to end this discussion by noting that genetic studies of different types of maize throughout the Americas have produced a phylogenetic tree mapping out the spread of maize through the hemisphere (Matsuoka et al. 2002; see also Blake 2015: 158–161; Pagán Jiménez 2011: 89–92). In these studies the maize ethnographically found on the Caribbean islands today is most closely genetically related to the maize found in southern Mexico and Guatemala, and only more distantly related to South American maize. Thus, though there is strong evidence that the earliest maize to enter the Caribbean was introduced from the south via Trinidad as early *Zea* began spreading throughout the Americas (Pagán Jiménez et al. 2015), it would seem that a later arrival of distinct varieties of maize entering from the Yucatán peninsula into Cuba and the Greater Antilles eventually dominated much of the genetic makeup of Caribbean maize in later times (see Chapter 8 in this volume for further discussion of maize in the Caribbean). Nevertheless, it was the Caribbean that provided maize with its modern name: “maize” is derived from the Hispaniolan Taíno word for the grain, *mahiz* (Barnhart 1988).

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16 Pre-Columbian farmers in the Guianas

Stéphen Rostain

Introduction

Agriculture has a long history in the Guianas, as in other parts of greater Amazonia – an extended area including the Amazon Basin and the tropical lowlands that surround it, as defined by Denevan (1976). The study of past agriculture in the Guianas cannot be dissociated from studies on the same subject elsewhere in this huge region of greater Amazonia. Humans probably rapidly began to manipulate plants soon after entering the tropical lowlands of South America more than 10,000 years ago. After centuries of harvesting wild plants, people induced species association, domesticated plants and developed agricultural techniques adapted to the forested and open environments that occur in the Guianas.

During most of the twentieth century, anthropologists considered Amazonia as a uniform tropical and pristine rainforest in which indigenous people carried out relatively simple kinds of management. Two main types of environments were distinguished and supposed to correspond to two different types of society, based on the simple idea that only the environment determines the stage of cultural development (Meggers 1996 [1971]). The forested area or *terra firme*, covering the majority of Amazonia, was seen as a uniform environment where the weathered, acid and nutrient-poor soils allowed only long-fallow slash-and-burn agriculture (swidden) (Figure 16.1). Because of such agricultural practice, scholars inferred that *terra firme* could sustain only sparse, semi-nomadic human populations. In contrast, the major river valleys (of the Amazon and its main tributaries) or *várzea* were considered as very suitable for agriculture because of their rich alluvial soils. The *várzea* was therefore inhabited by dense, sedentary populations (Meggers 2003 [1971]).

The reality has turned out to be somewhat subtler and more diverse, including a variety of regional systems showing a wide range of domesticated native species and elaborate techniques. The opportunistic use of specific soils and the adaptation to local conditions suggest that there was a remarkable domestication of landscapes by precolonials (Rostain 2012).



Figure 16.1 Wayana slash-and-burn field, typical of long-fallow shifting cultivation, Upper Maroni, French Guiana (photo by J. Hurault).

Among the main references on plant domestication in Amazonia and the Lowland Neotropics are works by Arroyo-Kalin (2012), Clement et al. (2010, 2015), McKey et al. (2012), Pickersgill (2007) and Piperno and Pearsall (1998). Plant use and manipulation, and management of populations of crops and semi-domesticated plants, and plant communities are explored by Balée (2013), Balée and Erickson (2006) and Posey (1985). Agricultural techniques, including swidden, *terra preta* and raised fields, and the domestication of landscapes by indigenous Amazonians are reviewed by Arroyo-Kalin (2012), Coomes (2004), Denevan (2001), Erickson (2008), Glaser and Woods (2004), Oliver (2008), Piperno et al. (2015) and Rostain (2012).

Environmental conditions

The Guianas cover some 1.8 million km² and include parts or all of five countries: Venezuela (states east of the Orinoco River: Amazonas, Bolívar

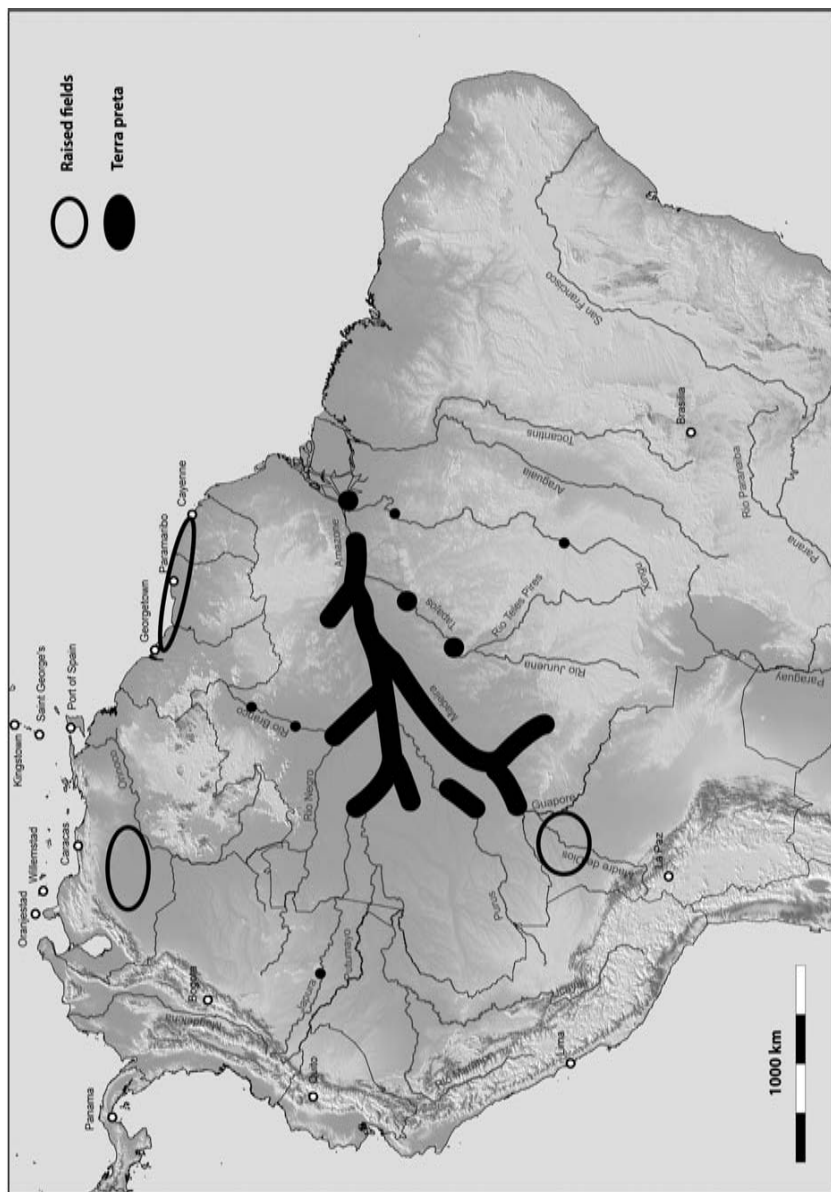


Figure 16.2 Map of Amazonia showing regions with pre-Columbian raised fields (circles) and areas with *terra preta* sites (in black) (drawing by S. Rostain).

and partially Delta Amacuro), Guyana, Suriname, French Guiana and Brazil (states north of the Amazon River and Rio Negro in Brazil: Amapá, Roraima and partially Amazonas). The Guianas are delimited by the mouth of the Amazon to the east, by the Atlantic Ocean to the north, by the Amazon River to the south, and by the Rio Negro and the Casiquiare canal to the west. The Casiquiare is a geographical anomaly because this river connects the upper parts of two different basins, those of the Negro and the Orinoco Rivers. Along their entire periphery, the Guianas are bordered by water (rivers and an ocean). They can thus be considered as comprising a vast continental island in greater Amazonia (Figure 16.2).

Four main types of landscapes can be distinguished. Moving from the interior toward the coast, they are: the *tepuies*, the upland savannas, the rainforest and the coastal plain (Rostain 2012). The first two are not well suited for agriculture. The *tepuies* are sandstone plateaus with steep and abrupt walls that can reach almost 3,000 m elevation, and the upland savannas, a mixture of shrubs scattered in large expanses of grasslands, are situated on sandy soils of low fertility. The central savannas are surrounded by the rainforest, which covers more than 80% of the Guianas. Amazonian forests are botanically and ecologically diverse, not only within sites but also among different parts of the region. They are home to the most diverse flora in the world, with more than 30,000 known species of vascular plants, of which 5,000 to 10,000 are trees (Silman 2007).

The Atlantic coast of the Guianas is a narrow Quaternary sedimentary plain stretching some 1,600 km between the mouth of the Amazon and the Orinoco Delta. The young coastal plain is a low, marshy, often seasonally flooded plain bordered to the north by mangroves on the mud flats along the seashore, and to the south by narrow and elongated sandy ridges – ancient beaches – that run parallel to the seashore (Rostain 2012). These geographical features separate the young coastal plain from the old coastal plain. Pre-Columbian farmers used different agricultural techniques in the inland forest and the coastal savannas.

Hunter-gatherers and plant domestication

The first human groups arrived in the Guianas 13,000–10,000 years ago (Cruxent 1972), corresponding to a climatic phase that was drier and colder than today's conditions (Van der Hammen and Absy 1994). Movement across the savannas, particularly for hunting, would have been difficult in the tall grass – often more than 2 m high – that quickly covers these areas when they are left undisturbed – thereby impeding hunters' view of their game. Hunter-gatherers probably adopted an approach similar to what is utilized in other parts of the world, that is, clearing the savanna by burning. Furthermore, it is possible that open and disturbed landscapes produced more plant resources for humans, and for the animals hunted by humans (Balée 2013).

Repeated burning by humans would have impacted the leading edge of the forest and the extension of the savannas. Simultaneously, these Paleolithic populations very likely developed a deep knowledge of plants and their life cycles. In all probability, after foraging and itinerant small-scale house gardening experiences, human groups began to manipulate plants and ecosystems at the end of the Pleistocene. So, the first human societies may have encouraged particular assemblages of species and carried out sustainable environmental alteration. Over time, extensive harvesting of wild plants changed to more intensive tending and cultivation and later to crop domestication.

Moreover, Amazonia was a major area of crop domestication, with 45% of the cultivated plants in the Americas coming from the Amazon (Clement 1999). At the time of the European Conquest, at least 85 native species were domesticated in Amazonia, including manioc (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), cacao (*Theobroma cacao*), tobacco (*Nicotiana tabacum*), pineapple (*Ananas comosus*) and chili pepper (*Capsicum* sp.), as well as numerous fruit trees and palms (Clement et al. 2015). Such domestication was made possible by the wide knowledge originally obtained by mobile hunter-gatherers. Domestication was probably a slow process of observation and manipulation of plants. Use of wild plants was also important in Amazonia where it is estimated that the indigenous populations used 3,000–5,000 non-domesticated species (Lleras Pérez 2012), bearing in mind that “it is not always easy to distinguish between wild and cultivated plants in South America, for there are many intermediate stages between the utilization of plants in their wild state and their true cultivation” (Lévi-Strauss 1948: 465). Despite this, “in Amazonia, the transition from primarily foraging to developed farming systems occurred by ca 4000 BP” (Clement et al. 2015).

First farmers in the Guianas engineered various agricultural systems, including variations of shifting cultivation, such as short-fallowing or agroforestry (Denevan 2001). The fundamental common aspect among all these agricultural techniques is that they are not destructive because they favor regrowth of forest cover after their abandonment. Furthermore, the exploitation of plants can be very simple, such as favoring the growth of certain non-domesticated species. Groups of mobile Paleo-Indian hunter-gatherers no doubt used similar practices which could favor the regrowth of edible plants along the routes they regularly followed (Posey 1985). The Paleo-Indian hunter-gatherers would have been the first to study their local flora and may even have better understood the properties of these plants than later farming populations.

For instance, manioc (*Manihot esculenta*), which is today the principal crop of slash-and-burn fields in the Guianas, has been chosen because this root crop presented a number of advantages, such as reproduction through cuttings, tolerance of poor soils, resistance to predators and parasites, and its capacity for “live storage” for more than two years in the ground (McKey

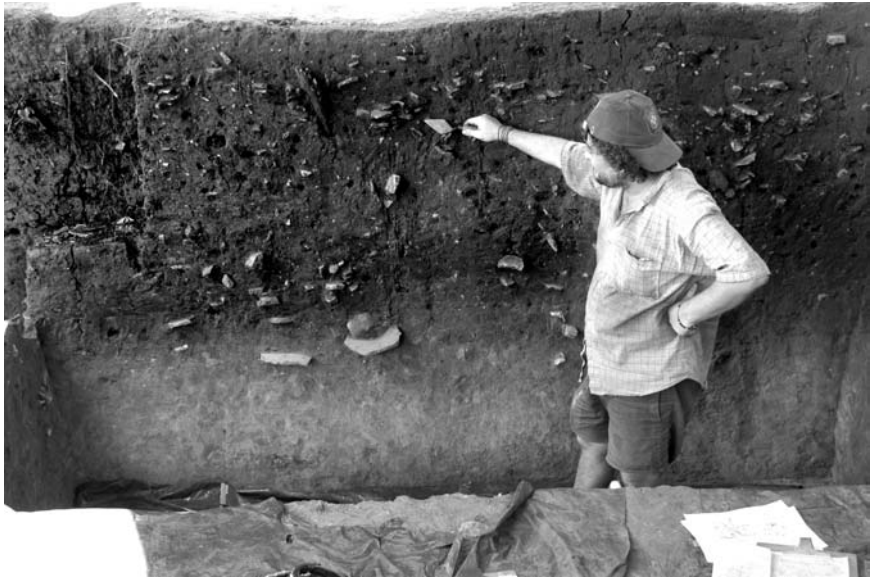


Figure 16.3 Thick cultural level of *terra preta* in the archaeological site of Hatahara, near Manaus, Middle Amazon, Brazil (photo by E. Neves).

and Beckerman 1993). Among indigenous groups of the Amazon, one crop normally dominates cultivation, often bitter manioc, maize (*Zea mays*), sweet potato or banana (*Musa*), but a number of secondary species are cultivated simultaneously. For example, the Wayana of French Guiana organize a territory of approximately two hectares per family, in which a parcel of at least 0.5 hectares is opened each year, where approximately 20 species are cultivated over a two-year cycle (Fleury 2000). The Wayampi of the upper Oyapock cultivate 35 species (Grenand 1981). Fruit trees are planted around the house and the surroundings of the village are cultivated. These contemporary case studies provide insights into how precolonials might have managed their fields.

Terra preta and agricultural earthworks

A particular type of *terra firme* farming was practiced in various parts of Amazonia on the fertile black anthropogenic soils called *terra preta* (Figure 16.3). Long-term human occupation – with short fallow periods and more intensive, fire-dependent, labor-demanding farming – greatly modified soils in ways that favored agriculture, creating anthrosols that have been named *terras pretas* or Anthropogenic Dark Earths (ADE). The excellent fertility of the *terra preta* soils is due to the presence of wood charcoal, organic material and anthropogenic microremains

(Arroyo-Kalin 2012). Tremendous interest in *terra preta* by archaeologists, geographers and pedologists has emerged in the last 20 years (Glaser and Woods 2004). *Terra preta* expanses measure between 0.1 and 5 hectares, although some exceed 300 hectares. Their average thickness is from 40 to 60 cm, but can be up to more than 2 m. *Terra preta* expanses may cover up to 0.1–0.3% of forested Amazonia (Sombroek et al. 2003). The first *terra preta* soils appeared 8,000 years ago, but they are most common throughout the Amazon between AD 450 and 950 (Petersen et al. 2001). Most *terra preta* sites appear to be a legacy of increasing farming populations in Amazonia during the late pre-Columbian period, ca. 2,000–500 BP (Neves et al. 2003). *Terras pretas* seem to be mainly located along the Amazon valley (McMichael et al. 2012). Although they are found in other places in Greater Amazonia, they have not yet been reported with certainty in the Guianas.

The adoption of agriculture and the development of large-scale agricultural systems on raised fields amplified landscape modification and domestication. These changes represented much more than a simple adaptation to the environment; they demonstrated a true management of landscapes.

Plant domestication was first conducted by hunter-gatherers and proto-farmers in the Guianas, but the intensification of landscape domestication resulted more from the expansion and action of sedentary farmers, especially on the coastal plain. In this flooded environment, in addition to acid, nutrient-poor soils, agriculture faces two other important constraints: drought in the dry season and flooding in the rainy season. In the absence of rice or other flooding-adapted crops, one of the ways in which farmers responded to these environments was to construct raised fields upon which to grow their flood-intolerant crops.

The most remarkable domesticated landscapes of the Guianas are the coastal savannas of Guyana, Suriname and French Guiana, where pre-Columbian farmers used an elaborate agricultural technique based on raised fields (Figure 16.4). These farmers are considered by scholars to be affiliated to two cultural traditions, defined on the basis of pottery assemblages: the Barrancoid (AD 300–600) and the Arauquinoid (AD 650–1400) traditions. Barrancoid groups were the first to build some raised fields in western Suriname. The Arauquinoid people subsequently extended this technique to a large part of the coast, building thousands of raised fields that reflected an impressive and an ingenious agricultural response to environmental constraints in the seasonally flooded coastal plain of the Guianas. To raise the earthen mounds, they used wooden shovels. Archaeological specimens of these shovels have been found in the swamps of western Suriname (Figure 16.5).

Such raised-field agricultural techniques are not known for the Amazon Valley. However, they were employed in the flooded savannas and *llanos* of the periphery of Amazonia: those of the Guianas coast (Rostain 2012), in

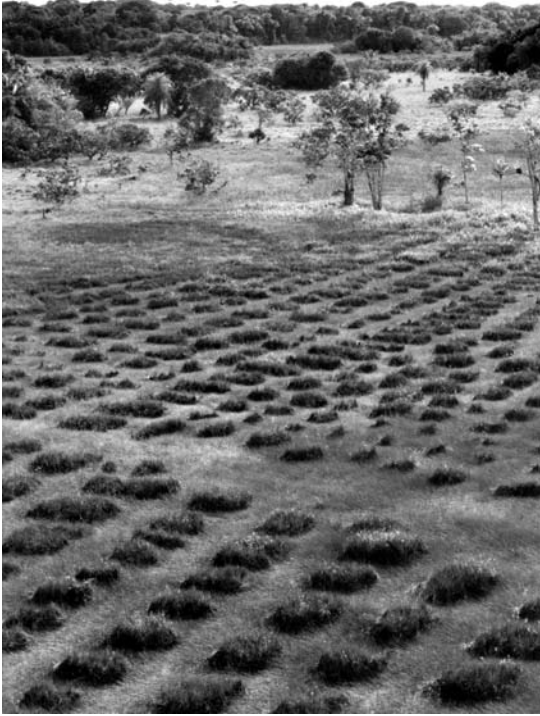


Figure 16.4 Complex of pre-Columbian raised fields in seasonally flooded savannas within the Guiana Space Centre on the central coast of French Guiana (photo by S. Rostain).

the western *llanos* of Venezuela (Denevan 2001), in the San Jorge Valley in Colombia (Plazas and Falchetti de Saenz 1981) and in the *llanos de Mojos* in Bolivia (Erickson 2008).

In the Guianas, the Arauquinoid people occupied a territory of approximately 600 km long and between 2 to 40 km wide from present-day Guyana to French Guiana, where the raised-field technique was intensively used for almost a millennium before European contact (Rostain and Versteeg 2004). Arauquinoid communities settled between the Berbice River in eastern Guyana and Cayenne Island in French Guiana. The highest density of raised fields is found in the east of the Arauquinoid territory, particularly between Iracoubo and Kourou in French Guiana, where the last Arauquinoid communities survived. In this area, it seems that almost every flood-prone spot was used for agricultural purposes. Complexes of raised fields have particular configurations. The form and size of agricultural mounds and their distribution depend on topography and water level, but

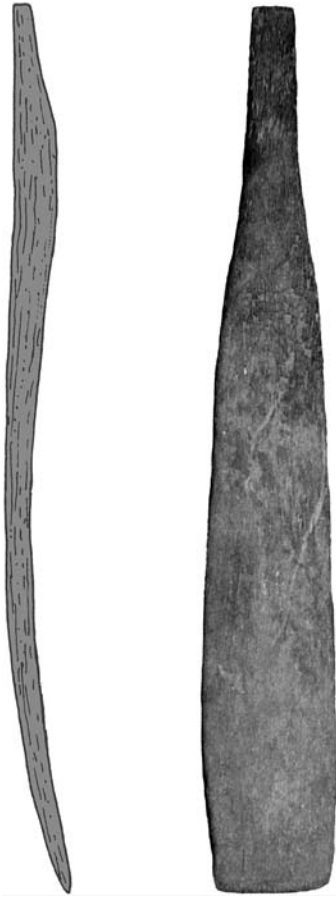


Figure 16.5 Wooden shovel dated to 790 ± 30 years BP (Versteeg 2003) and found in a marsh near raised-field sites in western Suriname (photo and drawing by S. Rostain).

variations of shape and organization can be seen within a single complex. For instance, in a raised-field complex located along the slope of a Quaternary sand ridge, large rounded raised fields are built in the deepest part of the swamp, while elongate raised fields follow the direction of the slope, presumably to allow easy drainage at the base of the ridge, whereas other elongate fields are laid perpendicular to the slope for optimal water retention on the upper part (Rostain 2012). Fields may have been oriented so as to speed up drainage in more flooded sites and retain moisture for longer periods in less flooded sites. Shape and layout of raised fields respond to specific constraints and reveal a subtle knowledge of various environmental factors.

Hydraulic constructions – canals and ditches – associated with the raised fields are specific to French Guiana (Rostain 2012). Straight canals enclose a flooded area. They were used for the drainage of excess water and, perhaps also as water tanks or fishponds. Canals can measure 50 m long and 5 m wide. Belt ditches are small, winding features of 1–2 m wide and up to 100 m long, enclosing groups of raised fields. These belt ditches prevented waterlogging of fields during the rainy season.

Although raised fields are the most common earthworks made by the pre-Columbian inhabitants of the Guianas coastal plain, these landscape makers also built other earth structures. Artificial residential mounds are associated with raised-field complexes in Suriname and Guyana (Versteeg 2003). Canals are frequently associated with agricultural structures in order to improve drainage, but not all canals had solely agricultural functions. Small rivers were in some cases diverted and canals were dug to facilitate transport. Similarly, raised pathways were built to cross the flooded areas. It must be noted that farming on raised fields was probably only one component of multi-activity subsistence systems and fishing, hunting, gathering and other activities completed raised field agriculture.

The most detailed interdisciplinary field studies on raised fields in Amazonia have been made in French Guiana and conducted by the present author. The first program was conducted between 1989 and 1991 (Rostain 2008). The second one was carried out from 2003 to 2007 (Rostain 2015) and the last one from 2007 to 2011 (McKey et al. 2010; Rostain 2012). Although Arauquinoid pottery was quite well-known before 2007, dates were too few to define a precise chronological frame. For that reason, 66 ^{14}C dates were obtained from samples collected in domestic sites and raised fields. For the first time, raised fields were dated with some degree of precision in the Guianas. Dating from domestic sites confirmed the chronology previously defined (Rostain 2008) and building of raised fields has been dated between AD 900 and 1300 in two complexes (McKey et al. 2010). The first Arauquinoid raised fields in the Guianas probably existed from AD 650 in western Suriname (Figure 16.6) (Versteeg 2003), but raised fields became common and widespread almost everywhere along the coast from AD 900 and up to at least AD 1400, i.e. before European contact (Rostain 2015).

The type of plants cultivated in raised fields is one the main queries often raised in academic circles. As a result of pollen and phytolith analyses of earth samples from various raised fields complexes along the French Guiana coasts, this query has been answered. Phytolith analysis indicated that maize and squash (*Cucurbita* sp.) were cultivated (Iriarte et al. 2010). Pollen of sweet potatoes and arrowleaf (*Xanthosoma*) have also been found, but in disturbed contexts (Chacornac and Rostain 2015). Moreover, phytolith analysis from raised fields was combined with the analysis of starch grains from ceramic griddle sherds of the nearby domestic dwellings (Figure 16.7), to check for any correlations between cultivated and consumed plants. Maize, manioc and chili pepper were cooked on griddles (Iriarte et al. 2010).

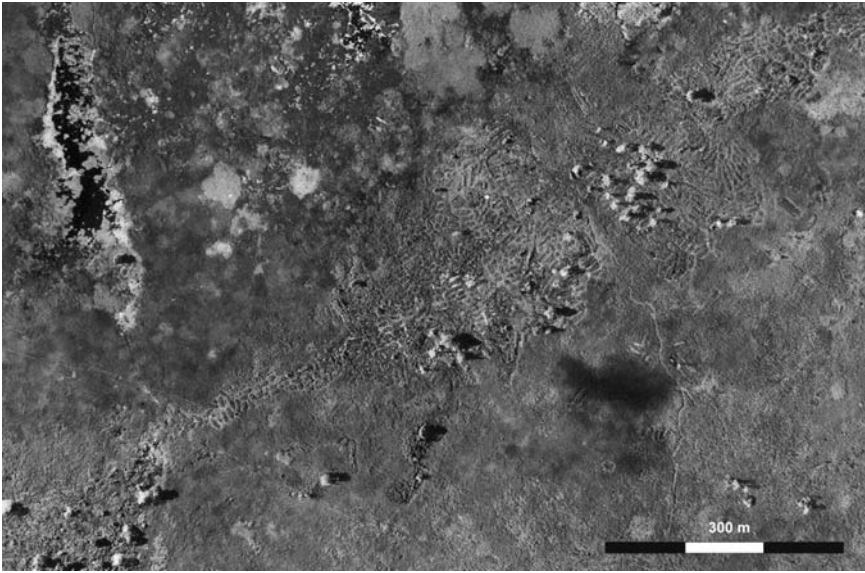


Figure 16.6 Flooded pre-Columbian raised fields in western Suriname, near Hertenrits (photo by the Dutch Geographic Institute).

All the samples provided maize remains, suggesting the importance of this crop on raised fields. Maize appears to be also predominant in other archaeobotanical data from elsewhere in Amazonia, where very little evidence of manioc cultivation is found. It is reasonable to conclude that maize played an important part in the pre-Columbian diet of Amazonian populations.

Phytolith analysis has clearly provided interesting insights into how raised-field soils were managed. Stems and leaves of maize have diagnostic phytoliths, and their presence in the earth samples indicates that these parts of the plant may have been left to decompose on the surface or even integrated in the ground after cutting as a mulch (Iriarte et al. 2010). Such practices can be observed today among the Haitian farmers cultivating modern raised fields in French Guiana.

Ecology of raised fields and mound-field landscape

Finally, raised fields have given rise to an interesting paradox in the context of tropical agriculture. The main plague for rainforest agriculture is the leaf-cutter ant, a fungus-growing ant that cuts pieces of leaves to bring back to the nest. These insects are particularly voracious. For example, some *Atta* species are capable of defoliating an entire citrus tree in less than 24 hours. Leaf-cutter ants can be considered as quite a nuisance to humans because



Figure 16.7 Broken griddle on the Sable Blanc site, western coast of French Guiana. This pottery originally lay on small stones as shown by the grey circle (photo by S. Rostain).

they defoliate crops and destroy plantations. However, *Acromyrmex*, another genus of leafcutter ants, also contributes to the preservation of raised fields. These ants act as “central place foragers” and as “mound builders” (McKey et al. 2010). As “central place foragers,” *Acromyrmex* workers carry large quantities of plants to the nest to feed their fungal symbiont. As “mound builders,” they construct deep nests, bringing subsoil to raised field surfaces. Ants move materials to the abandoned raised fields where they

make their nests. Moreover, transport of material to surfaces of abandoned raised fields partially compensates for losses due to erosion and helps to maintain mound heights. By reducing the erodibility of raised fields and by transporting materials to them, thereby compensating erosional losses, communities of ecosystem engineers on raised fields maintain the concentration of resources (and organisms) on raised fields and their depletion in the surrounding matrix (see McKey et al. 2010).

However, ants are not the only ecosystem engineers that contribute to maintaining the human-made structures. Other ecosystem engineers – termites, earthworms and even plants, via their roots – also contribute to the preservation of pre-Columbian raised fields up to the present day (McKey et al. 2010; Renard et al. 2013). Each has played a role, some more important than others.

Ecology of seasonally flooded tropical savannas is complex, specifically as it relates to understanding raised field agriculture in these areas. In fact, some regular mound-field landscapes of natural origin sometimes resemble agricultural raised fields (McKey et al. 2014). Ants nests like the *tacurues* in the south of the continent are preferentially built in ancient rice fields or pastures. In the llanos of Mojos, in Bolivia, raised fields are mixed with natural mounds made by termites or ants. Along the Upper Rio Negro in Colombia, mound-field landscapes were previously considered as human made (Reichel-Dolmatoff and Reichel-Dolmatoff 1974). In fact, they result from natural processes, because these huge mounds have been built by giant earthworms without any human intervention (McKey et al. 2014; Zangerlé et al. 2016). Such cases demonstrate that the boundary between Nature and Culture can at times be problematic.

It is often claimed that Indigenous people always burnt coastal savannas, as they do today, so that the impact of human use of fire has a long history in this environment. This opinion has been recently refuted, for at least one site, by data provided by a high-resolution 2150-yr palaeoecological record from a French Guiana coastal savanna (Iriarte et al. 2012). The results, combining pollen, phytolith and charcoal analyses, reveal unexpectedly low levels of biomass burning associated with pre-1492 savanna raised-field agriculture and a sharp increase in fires following the arrival of Europeans. In fact, although fires are intensively used today for agriculture in the rain-forest and on the coast, pre-Columbian raised-field farmers appear to have limited burning, probably to improve agricultural production by conserving soil organic matter and using plant remains as mulch. The charcoal record indicates that extensive fires in the seasonally flooded savannas of French Guiana are a post-Columbian phenomenon resulting from events set in motion by the decimation of indigenous populations (Figure 16.8). Before European contact, pre-Columbian raised-field farmers appeared to have practiced some form of fire control in the coastal savannas of the Guianas.

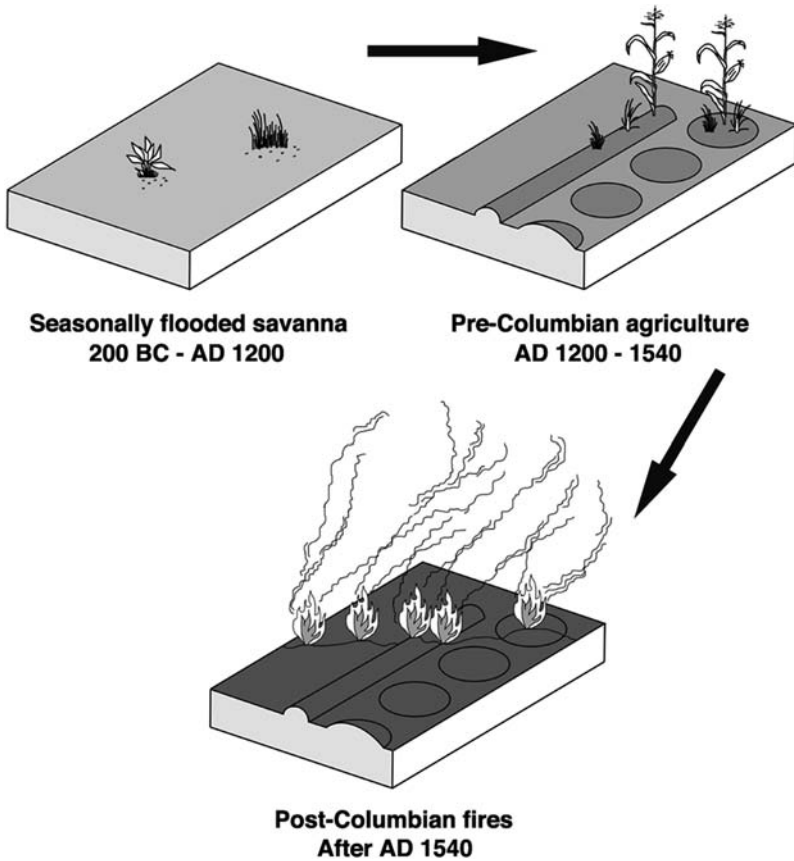


Figure 16.8 Sketch drawing showing vegetation and fire changes in coastal savannas of French Guiana as inferred from analysis of pollen, phytoliths and charcoal from a core (drawing by S. Rostain in Iriarte et al. 2012: fig. 4).

Conclusion

The reading of Guianas landscape from a historical ecology point of view shows a continuum from the pristine forest 15,000 years ago up to anthropogenous landscapes in the last centuries before the European Conquest. One of the major conclusions of recent investigations on this topic is that plant domestication and pottery making began in the tropical lowlands earlier than in the Andean area. In Amazonia, the main “domesticators” were the Paleo-Indian nomadic hunter-gatherers who manipulated and tested various species to select, promote and manage the most useful ones. Then, Amerindians experimented with various agricultural techniques, including agroforestry, slash-and-mulch, slash-and-burn,

domesticulture, ADE and earthworks. In the Guianas, the most impressive technique was without any doubt the raised-field agriculture, where mainly maize was apparently cultivated. Remains of these mounds located in flooding areas along the coast constitute the most important heritage of pre-Columbian farmers in the Guianas. Recent studies in historical ecology on raised fields show that the modern landscape of the Guianas has been co-built by natural ecosystem engineers and human inhabitants during centuries.

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17 From cooking pits to cooking pots

Changing modes of food processing during the Late Archaic Age in French Guiana

Martijn M. van denBel, Sebastiaan Knippenberg, and Jaime R. Pagán Jiménez

Introduction

Sedentary societies and the presence of horticulture, ceramics, and grinding tools characterize the initial Early Ceramic Age (ECA) of northern Amazonia (Roosevelt 1999a, 1999b). In French Guiana, this is considered the result of a neolithization process (Grenand and Grenand 1997; Lavallée 2005) which eventually became more evident during the first half of the first millennium AD (Rostain 2012: 104).¹ Perhaps more importantly, this process had already started during the Archaic Age and intensified during the drier Middle Holocene Period (6000–4000 BP) or Late Archaic / Early Ceramic Age. This so-called Holocene Drought in Amazonia was also recognized in French Guiana by Ledru (2001) and Tardy (1998). It may well have incited the Amerindian population to manage tuberous plants and maize (*Zea mays*) in a different manner or to cultivate them more adequately or extensively. Although the exact manner in which they may have carried out this activity is still unknown, essentially this type of agriculture resulted in significant changes in food preparation, subsequently altering the Meso-Indian way of living as well as society as a whole. It is believed that certain groups developed extensive agriculture and (semi) intensive strategies in order to produce food (Denevan 2001; Oliver 2008). These initial Early Ceramic Age populations developed an important and wide variety of domesticated and semi-domesticated plants, root crops (e.g. manioc [*Manihot esculenta*]), and arboriculture, whereas other pre-Columbian populations predominantly grew maize in northern Amazonia (Harris 2006; Perry 2004, 2005; Perry et al. 2006; Roosevelt 1980).

The first Archaic sites in French Guiana yielded important new data to the Formative Age. These include food cooking pits and early ceramics dating back to the second half of the third millennium BC (Figure 17.1). These features, found at the two important French Guiana sites of Eva 2 and Chemin Saint-Louis (henceforth called Saint-Louis) situated in the Pleistocene hinterland of the coastal Holocene plains, show that mainly maize and sweet potatoes

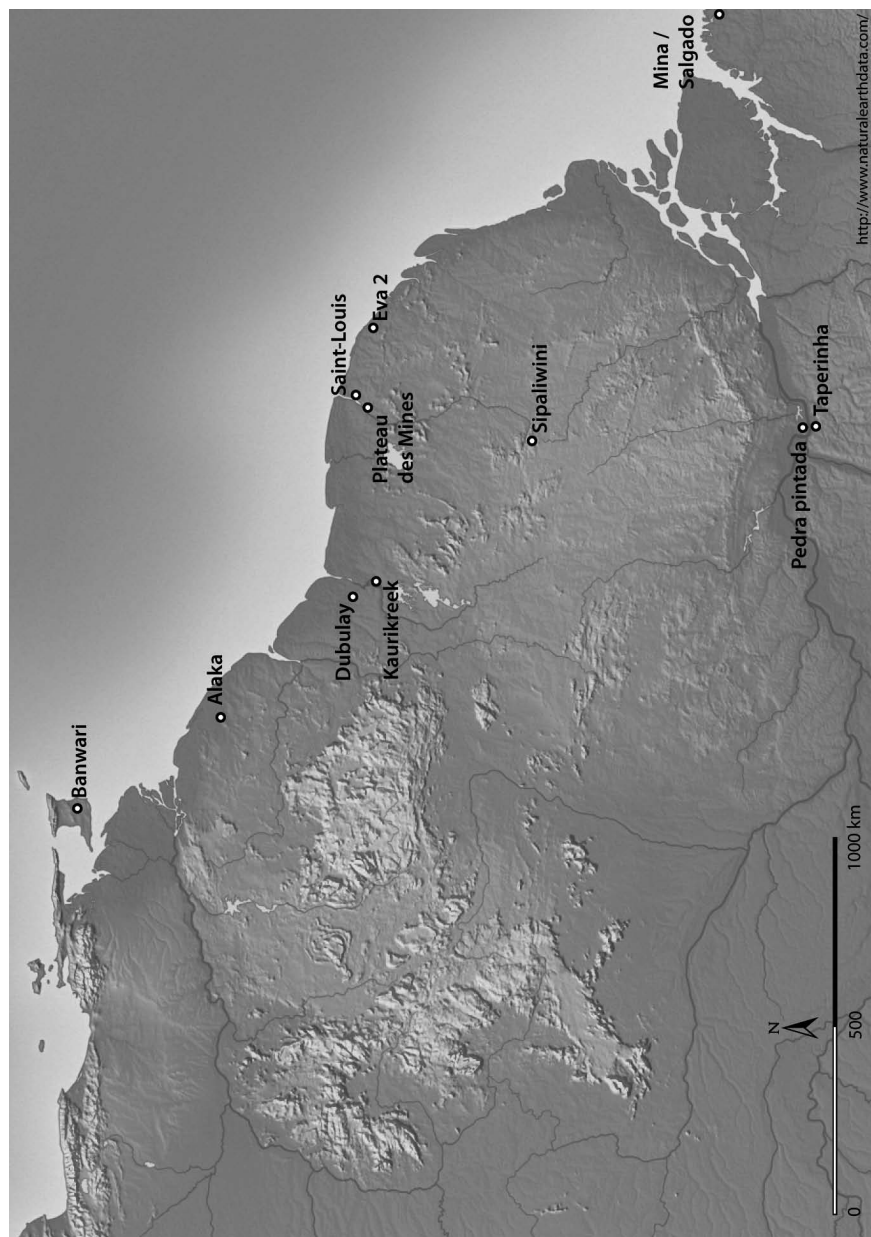


Figure 17.1 Map of the Guianas with location of the discussed sites (Produced by M. van den Bel).

(*Ipomoea batatas*) were processed by means of grinding tools, hot-rock cookery, and ceramic containers.² The Formative Age, i.e. the transition from the Meso-Indian to the Neo-Indian way of life, is regarded by many archaeologists working in Amazonia as a barely known but crucial period of transformation, shifting from a 'shell-fish economy toward a mixed system of root horticulture, fishing and hunting' (Roosevelt 1999a: 322–323). Oliver (2008: 208) underlined the importance of this period by adding that during the Formative period (c.4500–2000 BP) settled village farmers and nascent complex polities emerged. However, Oliver also added, just as Roosevelt did 15 years before, that 'it is precisely during the Formative Age that data on economy ... is very scarce. The lack of knowledge about the critical shift from incipient to intensified agro-economy is one of the big "unknowns" in Amazonian prehistory' (2008: 208).

In the following discussion, the sites of Eva 2 and Saint-Louis will be introduced, followed by a description of the archaeological materials (artifacts and features) and its cultural characterization relating to early plant management. In our conclusion, a synthesis will be provided of these sites' food processing and subsistence economies and cultural affiliations.

The archaeological sites

The Late Archaic site of Eva 2

The Eva 2 site is located on top of a hillock of the White Sand Formation, juxtaposed between the Precambrian Shield and the Pleistocene savannahs in central French Guiana.³ The excavations revealed an ancient buried A-horizon, or palaeosol, at 80–100 cm in depth within the White Sand Formation (van den Bel et al. 2006). This layer yielded numerous polished tools, large quantities of almost exclusively quartz lithic *debitage* and fragmented quartz tempered ceramics. Partially within and below this layer, more than 200 pits were found containing concentrations of fire-cracked quartz rocks spread over the bottom. These pits have been interpreted as ovens or cooking pits where the hot rocks functioned as heating material to slowly cook food that was laid on top of it and subsequently sealed with earth (van den Bel 2010). Interestingly, some of these ovens also contained fragments of pottery. The majority, however, do not contain ceramics. These latter ovens have been dated and attributed to the Late Archaic Period whereas the pits containing ceramics have been dated and attributed to the initial Early Ceramic Age (van den Bel 2010: 64, table 1) (Figure 17.2a).

Since more than half a hectare was excavated through compliance archaeology, a spatial distribution of three distinct zones with rock-filled pits was discerned (Figure 17.2b).⁴ Within each zone, each consisting of approximately 70 rock-filled pits, crescent-shaped alignments of four to five pits were found forming so-called 'batteries' and perhaps representing

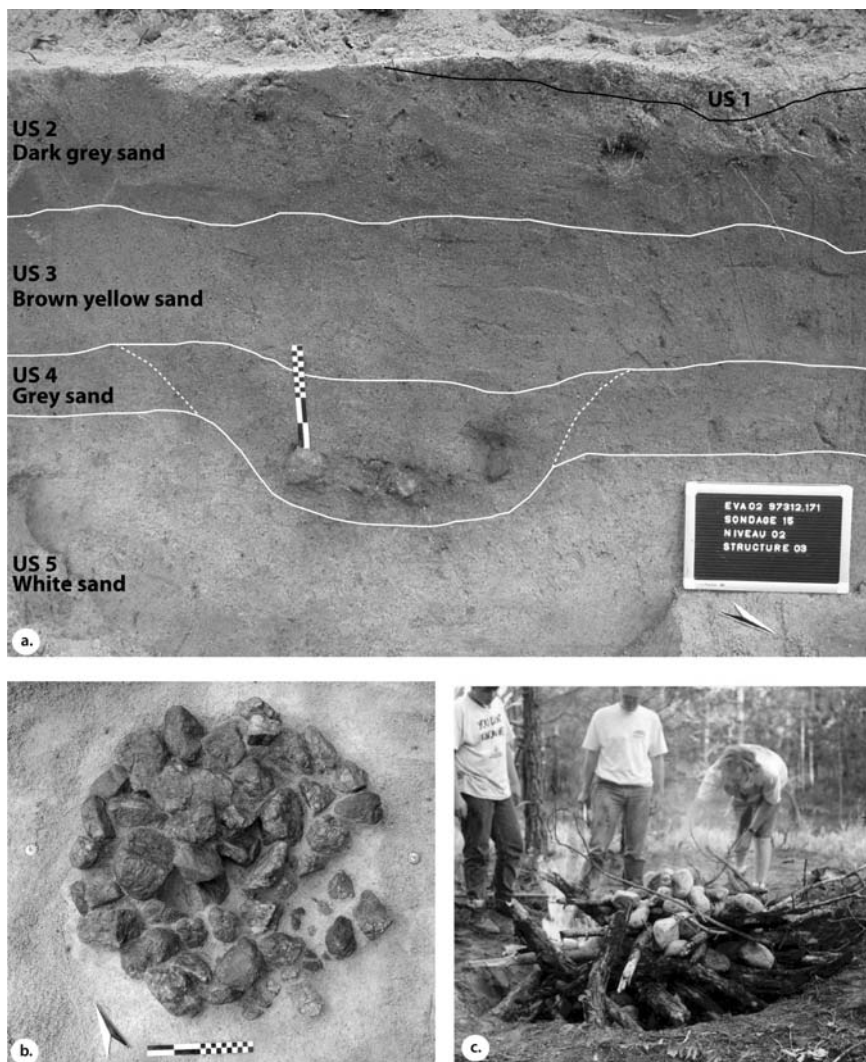


Figure 17.2 (a) Stratigraphy of Eva 2 with a rock-filled pit in section; (b) zenithal photograph of a rock cluster; (c) photograph of an experimental rock-filled pit (courtesy A. Thoms).

simultaneous cooking events (van den Bel 2010). Similar, but larger and slightly older (*c.*7000 BP), Late Archaic Age rock concentrations, or ‘beds,’ have been found at Plateau des Mines (White Sand Formation) in western French Guiana (Mestre and Delpech 2008) and earth-lined pits at San Jacinto in Colombia (Oyuela-Caycedo and Bonzani 2005). Similar to the North American Archaic Age (Dering 1999; Thoms 2003, 2009), it might

well be that these food-processing or cooking pits are emblematic of the (Late) Archaic Age in French Guiana and as well as in other parts of northern South America (Figure 17.2c). Little published comparative data however are available to support this (van den Bel 2010).

The initial Early Ceramic occupation of Saint-Louis

The Saint-Louis site is located about 160 km to the west of the Eva 2 site (van den Bel et al. 2011) (Figure 17.1). It is situated on the youngest river terrace of the Maroni River (the bordering river with Suriname) which is dated between 10000 and 6000 BP (de Boer 1972: 19; Palvadeau 1999: 174). Once the Maroni River had abandoned this streambed, sediment was deposited only during flooding, resulting in the formation of a natural levee that was inhabited shortly afterward by the Amerindians. Large scale excavations (140 m × 40 m) revealed a possible Late Archaic and without a doubt an initial Early Ceramic Age occupation (Phase 1) on this higher levee, whereas the much recent Early Ceramic Age (Phase 2) occupation was present throughout the excavated perimeter and notably in the fan-area where Archaic material was absent (van den Bel 2012).⁵

During mechanical excavation, archaeological material was hand-collected in 5 m × 5 m squares in a dark earth layer ranging between 40 and 80 cm in thickness (Figure 17.3a). At the bottom of this layer, recognized only at the higher levee, distinct quartz-tempered ceramics were collected. Once this find layer had been scraped off, two charcoal-filled pits and two ceramic deposits were found, containing similar ceramic material with radiocarbon dates going back to the second half of the third millennium BC (Figure 17.3b). Interestingly, older dates (e.g. 3400 BC) have been obtained for the levee area; unfortunately, however, they were not clearly associated with the archaeological material.

Material and cultural characterization

Lithics

Eva 2

The Eva 2 site produced a very rich lithic assemblage (Delpech in van den Bel et al. 2006). The large majority (99%) consisted of quartz flaked stone that was reduced following an expedient bipolar technology aimed at the production of small flakes. A small, but important, portion of the lithic assemblage consisted of ground stone tools (e.g. axes, mortars, pestles), as well as use-modified food processing implements (e.g. (edge) grinders, milling stones, or *metates*) (Figure 17.4a–c). To obtain a better understanding of the quartz flake tool technology, a small area containing the intact palaeosol was selected for more systematic artifact retrieval using mesh-screens.

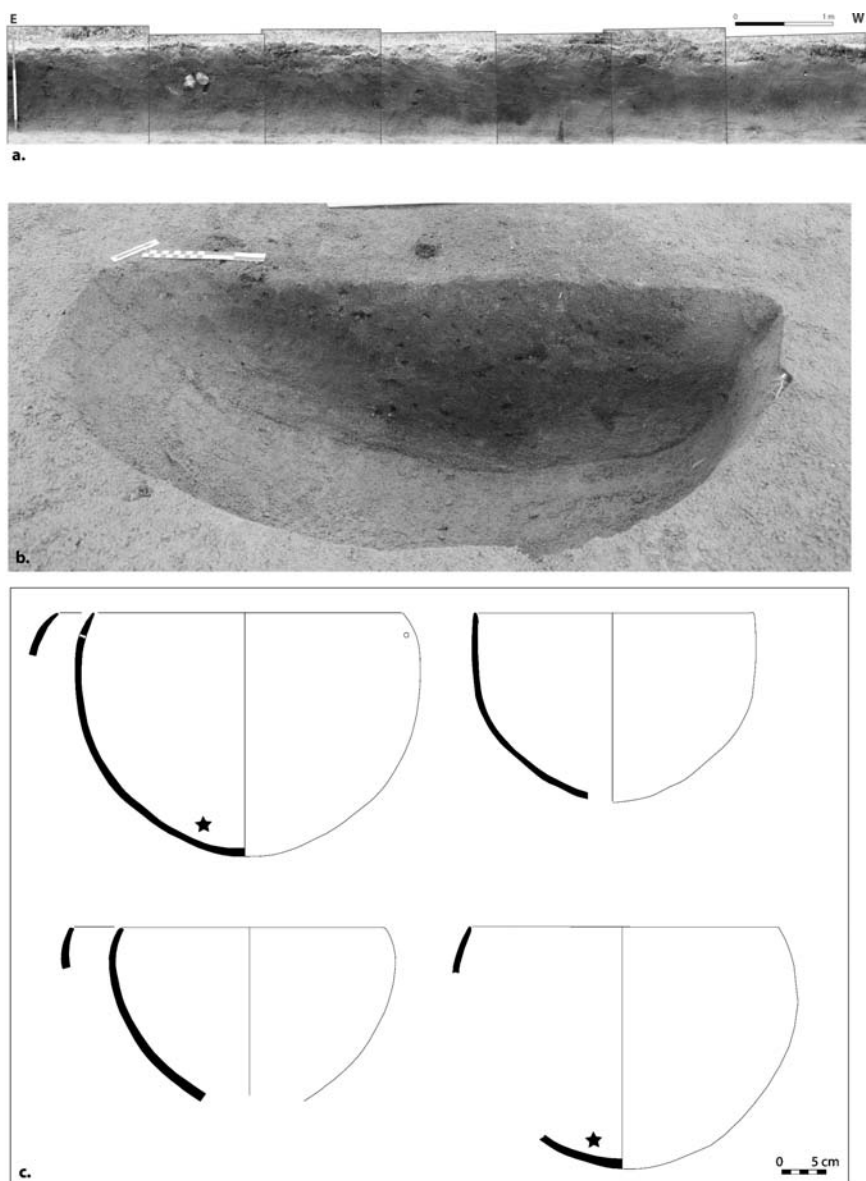


Figure 17.3 (a) Photo by P. Texier (Inrap). Dark earth in lower back-fan area of Saint-Louis; (b) Photo by M. van den Bel (Inrap). Cooking pit; (c) Drawings by M. van den Bel (Inrap). Vessel shapes attributed to the Early Ceramic Age, Phase A (stars indicating starch grain samples).

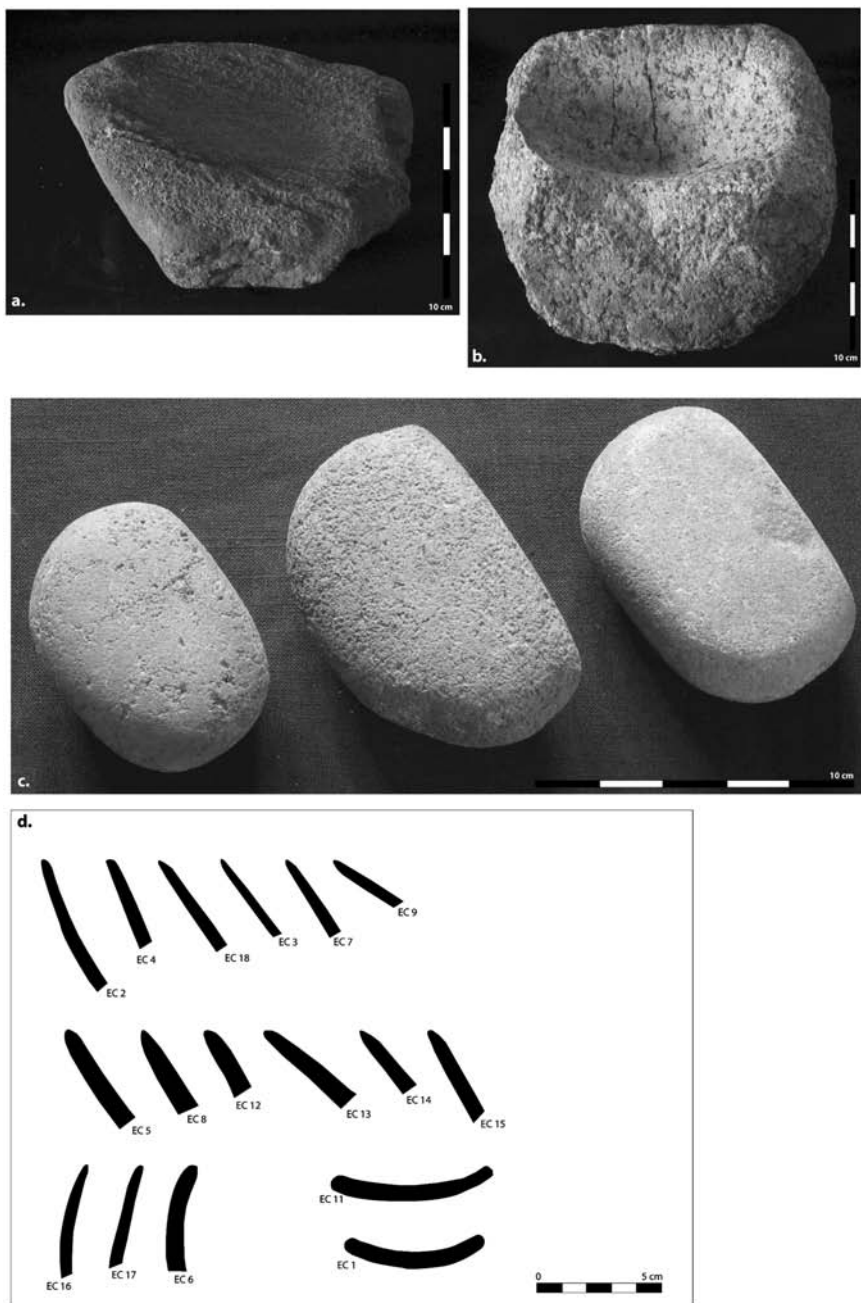


Figure 17.4 Grinding tools found at Eva 2: (a) metate; (b) mortar; (c) edge-grinders (photographs (a) to (c) by S. Delpech (Inrap)) and (d) ceramics: rim sherds and bases (drawings by M. van den Bel (Inrap)).

The area was divided into 76 units measuring 1 m × 1 m, which were excavated in three arbitrary layers of 5 cm. This yielded more than 12,000 quartz flakes. This clearly showed that there was an important quartz flaking industry based on relatively coarse saccharin and, more rarely, translucent and milky quartz varieties. Notably, the latter type only showed some simple retouching, stressing the expedient nature of this lithic production template.

Four milling stones from the archaeological layer were sampled for starch grain analysis. Sediments from these artifacts were then processed and analyzed for their starch grain content. Two of these use-modified artifacts were made of quartzite while the other two were made of igneous stones. The starch grain analysis showed that four important plants were ground on these milling stones: maize, sweet potato, arrowroot (*Calathea* spp.), and jack bean (*Canavalia* spp.) (Pagán Jiménez et al. 2015). These results are striking as the latter two are not very common in present-day processing of plant foods. Furthermore, the presence of maize and sweet potato starches can now be associated with a Late Archaic and Early Ceramic Age subsistence economy in French Guiana. The absence of manioc is interesting and striking as well. Perhaps these tubers were processed by an alternative production mode, without grinding or milling, or it could be that they were not eaten at all during this Formative Period. More work, however, is certainly needed to either confirm or disprove these various assumptions.

Saint-Louis

About 80% (N=3955) of the hand-collected lithic material consisted of quartz, either angular blocks or water worn pebbles (Knippenberg 2012). Both coarse and fine saccharin, as well as finer milky and translucent quartz had been utilized. All these materials were locally reduced in order to create proper flakes that served as cutting, scraping and grating or drilling tools. Quartz also functioned as the raw material for hammer stones.

Three quartz core reduction modes have been identified (Modes 1–3), which were all aimed at producing flakes to be used as tools. These can be attributed to two lithic traditions. Two modes have a strong opportunistic character and were predominantly applied to the saccharin quartz varieties and to a lesser extent to the milky quartz (Modes 2–3). Cores were reduced from any angle possible and no standardized procedure was followed. These modes are associated with Phase 2, and to a lesser extent with Phase 3.

Mode 1 represents a more standardized reduction strategy of bifacially reducing small cores to obtain small flakes. Only small water worn pebbles of the milky quartz have been reduced in this manner. This mode has been associated with Phase 1, the Late Archaic and initial Ceramic Age (Figure 17.5a).

For all modes, secondary chipping of the flake edges did not play an important role. A very small percentage of only 0.5% of the flakes bear intentionally retouched edges. Around 5% of the flakes exhibit macroscopically visible use-wear. These percentages represent the minimal number of



Figure 17.5 (a) Small milky pebbles; (b) grinding tools from Saint-Louis: (i) edge-grinder; (ii) metate. (Photographs by S. Knippenberg (Archol BV)).

flake tools, as only a part of the employed activities would result in the formation of macroscopically identifiable use-wear. A microscopic study of a number of utilized flakes to obtain a better view of the use-wear (polish), did not produce any results due to the natural polish most of the quartz artifacts possessed. Interestingly, another more ancient tradition is suggested by the presence of a very small number of large flakes made of a fine-grained patinated chert. These may relate to a blade-technology and may represent the presence of Early Archaic, or Paleo-Indian, Amerindians at the site or within its direct surroundings.

In addition to flake tools, the Amerindians at Saint-Louis also manufactured and utilized a variety of manufactured and use-modified core tools, for example, axes, grinding stones, abrading stones, hammer stones and anvils (Figure 17.5b). The fragmented nature of these stone tools unfortunately hampered to a large degree efforts to correctly identify all of the tool types. It clearly shows that the excavated lithics mainly represent refuse material.

Among the core tools, we observed a large variety of rock types. On the one hand, this indicates that the Amerindians chose specific materials for specific purposes. For example, granite almost exclusively served as a passive grinding material. On the other hand, the large variety reflects, to a certain degree, the opportunistic utilization of a wide range of available rock types. This was clearly reflected in the different materials that were used for axes.

One quartz milling stone base, detected in the vicinity of the Early Ceramic Age features at the levee in the lowest level of the *terra preta* layer, has been attributed to the early period (Phase 1). Starch grain analysis of samples from this *metate* has shown the presence of ground maize, beans and sweet potato (Pagán Jiménez 2012: 86, table 3; Pagán Jiménez et al. 2015).

The ceramics

Eva 2

Heavily weathered pottery fragments were found dispersed not only in the palaeosol, but also in various rock-filled pits. Any surface finishing or possible painted decoration was rather difficult to distinguish. However, this erosion clearly revealed a coarse sandy and/or pounded quartz tempered paste with a light brown yellowish core. As much as 93% (N=1797) of the ceramic assemblage are represented by body potsherds measuring less than 5 cm (mean weight: 7 g), unfortunately bearing very little morphological information. The small size of these potsherds may be due to trampling. This level of fragmentation has made it difficult to differentiate between a rim and the edge of a coiled body. Only 18 constituent elements have been recognized, including 15 rim and 3 base fragments. The rim potsherds have pointed lips. Their wall thickness varies between 4 mm and 8 mm, revealing

a rather thin ware. Diameters of the pots vary between 20 cm and 28 cm representing 12 small open and 3 restricted bowls (Figure 17.4d). Four fragments featured a careen or keel; one of which measured 30 cm in diameter. Collar or neck fragments were recorded but are too small to provide any meaningful information. Only three base fragments were found, allowing us to define its parameters. They have a convex shape and were manufactured by means of enrolling a coil that is still clearly visible. Its diameter is rather small and measures *c.* 5 cm. Finally, one large concentration of body fragments weighing 3.3 kg probably belonged to one large spherical (restricted?) vessel but no rim or base fragments were identified to better characterize this vessel. Interestingly, clay griddles are absent at Eva 2.

The ceramics are exclusively tempered with coarse grained sand, representing *c.* 20% of the paste (see Orton et al. 1993).⁶ The abundance of silica (quartz/SiO₂) in these potsherds has been confirmed by a mineral analysis of two potsherds (van den Bel et al. 2006). However, possible vegetal material, i.e. black dots or burnt “fibers,” were also identified in a few potsherds. It is unclear as to whether they were added intentionally or represented burnt roots left in the raw clay material.

Saint-Louis

As mentioned earlier, the earliest ceramics of Saint-Louis are quite dissimilar when compared with the more recent ceramics attributed to Phase 2 (AD 0–400) and Phase 3 (AD 900–1300). Unfortunately, they are only represented by a few diagnostic elements, including seven bases, eight rims and three complete vessel shapes (N=338). These ceramics are characterized by means of a coarse sand temper with possibly coarse pounded quartz that is easy to recognize on the eroded surface of the potsherds. Only two vegetal tempered specimens were identified (cf. Eva 2).

The exterior of the ceramics was heavily eroded, but displayed a characteristic pale yellow color (10YR 7/4–6). The smoother interior was better preserved, with a faint brownish color (7.5YR 6/3–4). No finishing techniques or decorations were observed (van den Bel 2012). The three complete vessel shapes, all found in the pits with ceramic deposits, have rim types which were also present in the material found in the dark earth layer. The absence of careens, necks and even griddles is noteworthy. The morphology of the complete vessels is fairly simple and consists of spherical, slightly restricted vessels. The bases are fairly thick, measuring between 9 and 15 cm. Their rounded almost pointed shape has a diameter varying between 5 cm and 8 cm. These bases were created by enrolling a large coil upwards and this technique is easily detectable with the naked eye. The wall thickness varies between 6 mm and 9 mm while the lips are flattened or pointed. The rim diameters vary between 28 cm and 35 cm and the height of these vessels is about 30 cm. The rims are straight or convergent while one specimen has two “suspension” holes at 2 cm below the rim. Both the morphology and

physical dimensions of the ceramic vessels suggest a utilitarian function, such as the cooking and preparation of food (Figure 17.3c).

Starch grain analysis of black soot, or crust, samples scraped off from the interior of these vessels has indicated the presence of maize, sweet potato and different arrowroots (*Calathea* spp.) (Pagán Jiménez 2012: 86, table 3). The starches showed signs of grinding/pounding as well as heating suggesting that a doughy mass and/or a stew may have been prepared in the vessels.

Discussion

Although both sites yielded early or incipient ceramics and similar radiocarbon dates, the feature distribution was different. Moreover, both sites are located on different geological formations, which might explain the absence of rock-filled pits at Saint-Louis, besides the slightly younger date of the latter. Concerning these pits, the excavations at Eva 2 and Plateau des Mines premiered the revelation of a set of characteristics with regard to the Late Archaic occupation in coastal (Pleistocene) French Guiana which hitherto were ‘hard to detect’ (Rostain 1994: 411). Based on the results of these excavations, the following observations were made:

- a) The presence of the White Sand Formations indicates that archaeologists need to watch out for buried occupation surfaces in these sediments.
- b) Such an occupation layer contains large quantities of lithic material of which the production of small quartz flakes (2 cm) is a primary interest of this opportunistic production mode.
- c) Multiple rock clusters can be found in shallow pits in or just below this layer. They are organized spatially in alignments and delimited zones. It is hypothesized that these clusters represent cooking pits, attesting a hitherto unknown food processing activity in the Guianas.
- d) The presence of grinding stones, mortars, pestles and edge grinders and other polished tools implies that there was another stage of food processing. This refers to the initial processing (grinding, pounding) of edible plants (e.g. various tubers, rhizomes, maize).
- e) The presence of incipient, or initial, ceramics are found in association to cooking pits.

The above-mentioned elements represent important characteristics of the late Meso-Indian or early Neo-Indian way of life concerning food processing. This predominantly applies to the cooking pits. While additional research is certainly needed, the evidence thus far suggests that they were used to cook a variety of foods that were locally available. Apparently, this was one of the major reasons for the occupation of Eva 2 next to quartz veins at the hillock of Eva 2. It also appears that this type of food processing represented an intermediate developmental stage in prehistoric cooking from open fire to

one involving the use of a ceramic container. Essentially, hot-rock cooking in cooking pits represents an important step in the process of culinary evolution during the Archaic Age. Therefore, these rock clusters seem to represent a chrono-cultural marker for the latter period (van den Bel 2010).

As the production of short flakes and cooking pits are characteristic of the Late Archaic subsistence economy, so was the use of various grinding tools (mentioned earlier). These are generally viewed as the 'most typical plant-processing lithic tools found at the early and middle Holocene sites in the Humid tropics' (Piperno and Pearsall 1998: 187). Reniel Rodriguez Ramos (2005) experimented with Archaic 'edge-ground cobbles' (Stothert 1985: 621–622) or edge grinders from the Greater Antilles, demonstrating that they had served to crush tubers and nuts (Figure 17.4c).⁷ These tools have also been identified at Plateau des Mines as *molette à morphologie de pilon* by Sandrine Delpech (Mestre and Delpech 2008: 51, fig. 20). Although samples from the edge grinders have not been analyzed, the milling stone bases from Eva 2 indicate that maize, sweet potato, arrowroot and jack beans were ground on these stones. On the one hand, the milling stones refer perhaps to the processing of raw tubers into a paste or half-product which is first wrapped in leaves as with *tamales* and then cooked in rock-filled pits (Rodriguez Ramos 2005: 8).⁸ On the other hand, it may also be a case in which the starchy products were cooked in the cooking pits prior to being pounded on the milling stones.⁹ Furthermore, it is also possible that the raw tubers, such as sweet potatoes and rhizomes, were grated before grinding them into a mushy paste. In fact, the presence of grinding tools, while marking a transition between Lithic and Archaic Ages, point to the importance of starchy foods among the Archaic populations (Gnecco and Mora 1997; Harris 1973; Simões 1981). This is reflected more generally in the Meso-Indian broad spectrum economy and exploitation of natural resources.

Concerning the Saint-Louis site (Phase 1), the earliest radiocarbon dates (Phase 1a) fall between 4500 and 4300 BP. These dates cannot be associated with archaeological materials, but we think they refer to the first human presence in this area. It is presumed that two large flakes can be attributed to these first human activities at the site, possibly representing a preceramic occupation that used a blade technology.

A second Late Archaic and/or initial Early Ceramic Age phase (Phase 1b) is represented by the small complex of slightly restricted heavy sand-tempered spherical vessels. These have been intentionally deposited in oval-shaped pits as well as in charcoal-filled hearths where corresponding radiocarbon dates were obtained. This early occupation is situated at the highest part of the levee where an old surface layer has also been observed. It is represented by two dwellings or activity areas both located around two charcoal pits, one of which features two pits with ceramic deposits. Although bones have not been encountered in these pits, they can be interpreted as inhumation graves, suggesting a more permanent occupation.

In addition to knapping quartz material, notably small milky river pebbles, the pre-Columbian inhabitants of Saint-Louis also produced pottery which was used to cook sweet potatoes, different kinds of arrowroots, and maize. It is believed that this type of starchy food was prepared by means of (edge?) grinding on *metates* or grating (Boomert 2000: 74). These activities produced a pulp that was subsequently used for preparing thick soups or mashed masses in cooking pots.

Food processing and subsistence economy

The large scale archaeological work at Eva 2 and Saint-Louis yielded the presence of (a) different types of grinding tools, (b) many clusters of cooking pits, (c) finds that suggested the production of small quartz flakes, and (d) possible evidence for the introduction of pottery, i.e. the Balaté ceramic complex. Furthermore, it also showed a long, continuous period of human occupation and relatively large site dimensions. The large quantity of cooking pits at Eva 2 and the presence of possible inhumation graves at Saint-Louis may indeed reflect a more permanent occupation of the site, indicative of sedentism. Growing and tending plants that need more care, such as maize, may well have triggered more permanent settlement and/or reduced the hypothesized “seasonal” cycles of Archaic Age groups (e.g. Gnecco and Aceituno 2004). Thus, the adoption of restricted cycles related to plant tending eventually incited the Amerindian population to settle down, which is accompanied by the introduction of ceramics. Indeed, it is generally thought that this early pottery can be better understood as a social and economic development than as the spread and adaption of a ‘rare invention’ (Raymond et al. 1998: 167), suggesting the development of more complex societies (Oliver 2008: 208).

The *metates* and spherical, slightly restricted vessels, evidenced the consumption of plants such as maize, sweet potato, arrowroot and jack beans. Recovered starches of these plants were predominantly affected by pounding and heating, which suggest the consumption of mashed masses, (thick) soups, and possibly *tamales*. The lithic food processing tools also showed the grinding of possibly pre-heated starchy organs, suggesting the kernels, roots or beans were subjected to different stages of cooking before being ground down into pulp or mass. The cooking pits may be a very likely candidate for this process.

To what extent the small quartz flakes relate to the food processing is still unclear (Oliveira Souza 2016). The reduction of tubers by means of small quartz flakes inserted in grater boards has been largely debated in Venezuelan archaeology by Perry (2001, 2002, 2005) and Barse (2008), but further research on quartz flakes is necessary in order to better understand not only the manner of production, but also to find out what the Amerindians attempted to do with it.¹⁰ Unfortunately, use-wear traces on quartz are difficult to recognize. Moreover, there is very little expertise on this matter in the Guianas contrary to surrounding countries, e.g. Colombia (Nieuwenhuis 2002), Venezuela

(Perry 2005), Guyana (Roth 1924), Brazil (Clemente-Conte et al. 2016) and the Caribbean (Walker and Wilk 1988).

As mentioned earlier, the Eva 2 and the first phase of Saint-Louis sites did not yield clay griddles or baking plate fragments. However, the second phase of the latter site yielded abundant fragments, revealing either the acquisition or local development of another mode of food processing/cooking that focused on the preparation of flatbreads, such as tortillas and cassava (van den Bel 2015a). This idea is contrary to current perceptions in Venezuela and the Western Guianas where griddles have been identified in the earliest ceramic complexes (Roosevelt 1980, 1997; Versteeg 1978).¹¹ However, they appear to be also absent from the Early Alaka Phase and only appear at Hosororo (Late Alaka Phase) about the second half of the second millennium BC (Williams 1997: 348) and in the Period 1 of Agüerito (Ware A) which is associated to the Saladoid series (Zucchi et al. 1984: 159, 175: fig. 7). In addition, the radiocarbon dates of Agüerito – where samples were taken at arbitrary 25 cm interval levels from the archaeological layer in small test pits (ibid. 179: table 9) – have provided random results that are untrustworthy. It is noteworthy that griddles have not been encountered in the deepest layer at Dubulay in eastern Guyana (Whitehead et al. 2010). These discrepancies may be a result of sample biases, and it is clear that further research is certainly needed in this area.

Focusing on the French Guiana data, it is evident that Eva 2 and Saint-Louis demonstrated the possible introduction of pottery during the third millennium BC. These ceramics materialize a possible novelty in food processing, which may be considered as a substitute for the cooking pits, following the North American hypothesis (Dering 1999; Thoms 2009). This change from the use of cooking pits towards ceramics, suggesting a regional diachronic development of Pre-Columbian *cuisine*, can be clearly discerned in French Guiana. The oldest occupation at Plateau des Mines shows the unique use of cooking pits and the absence of ceramics. These latter containers were introduced somewhat later at Eva 2, where they co-occur alongside cooking pits. At the later early occupations of Saint-Louis, cooking pits have disappeared and only ceramics have been found. Again, as mentioned earlier, the absence of clay griddles at both Eva 2 and Saint-Louis (Phase 1b) stress the importance of ceramics as cooking pots in which starchy masses, thick soups or stews were prepared. Considering the similar dates of the early ceramics found at both French Guiana sites, and the difference in dominant vessel shapes, it is possible that (a) these sites were inhabited by different (ethnic) groups and/or (b) the difference in site location may have encouraged different types of activities needing a different set of ceramic assemblages (cf. Boomert 2000; van den Bel 2015a). Both ideas are supported by the absence of oven pits at Saint-Louis and the absence of charcoal pits and possible burials at Eva 2.

Finally, another important trait of the Archaic French Guiana sites is their location on the White Sand Formation, as evidenced at Eva 2 and Plateau des Mines. Although we have little conclusive evidence concerning the geo-morphological origins of this geological formation, the presence of an

Archaic occupation level at *c.*1 m deep, is particularly interesting and requires further geo-archaeological research (Vincent Freycon, personal communication, 2013). However, the detection of such sites is rather difficult without any mechanical means or systematic auger testing. Discovering such sites may require a stroke of luck during field walking. It may partially explain why these type of sites were not found earlier, with the exception of individual finds, such as the Jorka point in eastern Suriname (Boomert 1980: 98). The Archaic Age people's decision to settle at the edge of these white sandy hilltops can also be linked to the procurement of raw quartz material emerging in veins in the vicinity of Eva 2 or in the small creeks at the foot of the Plateau des Mines sites. Therefore, it is believed that Archaic sites are also present on White Sand Formations in Suriname and Guyana, despite the fact that none has been found at the moment to our knowledge.

In addition to this site location preference, the radiocarbon dates suggest that these Late Archaic occupations appear generally at *c.*6000 BP in French Guiana. This indicates a possible correlation between the flattening out of the mean sea level for coastal sites and the onset of the so-called Holocene drought. Interestingly, this particular date of *c.*6000 BP also represents the end of sedimentation of the Phase IV Terraces in the Lower Maroni River, as seen in French Guiana. Moreover, it corresponds well with the earliest radiocarbon dates for the Alaka Phase and Mina sites along the northern South American littoral, with the exception of the Middle Amazon River and the island of Trinidad. All latter sites, however, are dominated by means of salt or fresh water shell middens that are lacking in French Guiana, but the site location exhibits similarity: Alaka and Eva 2 are situated upon higher Precambrian hillocks overlooking the swamplands of the Early Holocene Plains (Williams 2003: 211–212). It can be presumed, although there is no archaeological evidence, that earlier Archaic sites were positioned more towards the mouths along river banks, of which many may have disappeared due to the Holocene sea rise.

Climatologically, another relevant event coinciding with the end of the flattening out of the sea level – the end of the Mara depositions and beginning of the Wanica transgression in Suriname – and the Late Archaic occupation along the coastal Guianas, is the so-called Holocene drought, placed between 6000 and 4000 BP. In French Guiana, this drier period is marked by means of large quantities of charcoal thought to represent predominantly forest or savannah fires, notably during Phases VI and VII, according to Tardy (1998). However, as Tardy has pointed out correctly, these fires may also have an anthropogenic origin revealing an increase in deforestation in order to facilitate agriculture. Instead of collecting or tending crops, people had now started to grow their own crops in patches of cut-and-burned/charred forest and/or along the edges of savannahs, thereby generating large quantities of charcoal. Whether this agricultural potential was exploited by a growing population remains an issue to be investigated, but it is evident that successive harvesting needs more (careful) tending, implying a further sedentism for these Late Archaic populations, or early farmers.

Cultural affiliation

The sites of Eva 2 and Saint-Louis share a number of characteristics with other Late Archaic and initial Early Ceramic Age, or Formative sites in the surrounding region, previously having been referred to as the 'North West South-American Littoral Tradition' (Willey 1971: 361). From 5000 BP, sites in northern Brazil, Suriname, Guyana, Venezuela and Trinidad produce similar radiocarbon dates, share the presence of an opportunistic bipolar percussion technique aimed at the manufacture of small quartz flakes, the presence of coarse sand-tempered ceramics and the use of multiple active and passive grinding tools. These seem to represent cultural markers for both the Late Archaic and Early Ceramic Age which share eventually many characteristics. Regional diversity, however, is present between the Orinoco and Lower Amazon Rivers, and for French Guiana relates mainly to the use of cooking pits and non-reliance on shellfish. In this section the following characteristics (lithic industry, early pottery and shell middens) are discussed in order to provide a larger context for the French Guiana sites and a basis for future archaeological research on the matter.

Based on the expedient flake tool industry, Eva 2 and Saint-Louis can be ascribed to the Ortoiroid series, as defined by Boomert (2000), Cruxent (1971) and Rouse (1992) for the circum-Caribbean region. Site locations at the mouth of the Maroni River (Saint-Louis) and on hillocks situated in the direct Holocene hinterland (Eva 2), appear to be common site locations for Archaic and Early Ceramic Age sites. Important examples are the Alaka Phase in northwestern Guyana (Williams 1992, 2003) and the Mina Tradition in northeastern Brazil (Bandeira 2009; Imazio da Silveira 1994; Simões 1981). These locations were chosen as they are situated in ecotones on the border of the mangrove coast and the forested interior. The exploitation of these diverse habitats may be reflected in the varied lithic toolkit, suggesting a broad spectrum economy that included the use of ground stone and use-modified food processing implements.

The combination of small quartz flakes, cooking pits and grinding stones is particularly interesting. Boomert stresses the importance of (edge) grinders by stating that: 'Although the function of the edge grinders at the Ortoiroid sites of Trinidad and South American mainland is not sufficiently known [at that time], these implements should be considered as the type artifacts of the Ortoiroid series' (Boomert 2000: 74).¹² He also splits the Ortoiroid series into an older Banwarian and a younger Manicurian Ortoiroid subseries. The latter displays more cultural differentiation as manifested in various regional complexes (Boomert 2000: 54). The Early and Late Banwari series are contemporaneous with Early Alaka of Guyana (6000–4000 BC). These early series are characterized by flaked choppers, grinding tools and pitted anvils. Similar tools made by means of crude percussion (e.g. choppers and large flakes or picks) were found

at the Plateau de Mines site in French Guiana but are absent at Saint-Louis and Eva 2, and can possibly be attributed to an earlier phase (see for comparison the choppers in Mestre and Delpech (2008: 58) vs. Boomert 2000: 59).

A second, more recent occupation of the Plateau des Mines (Mestre and Delpech 2008: 70) resembles Eva 2 more or less and can be dated to around 3500 BC. This occupation corresponds to Late El Conchero (Cruxent 1972: 39–40), Late Alaka (Evans and Meggers 1960: 38–53; Williams 1992, 1997, 1998, 2003) and Early Mina complexes with regard to the Atlantic coast (Bandeira 2009; Imazio da Silveira and Schaan 2005; Simões 1981; Simões and Côrrea 1971) and the Amazon River (Gaspar and Imazio da Silveira 2000; Roosevelt 1995; Roosevelt et al. 1991).

The hitherto unknown ceramic series of Eva 2 and Saint-Louis have been attributed to the Balaté ceramic complex based on their contemporaneity, despite the fact that both assemblages have distinct vessel shapes, notably in dimensions and wall thickness (van den Bel 2015a). This difference is probably functional and can be related to their dissimilar geological settings: the river terrace versus the White Sand Formation.

Early French Guiana wares share numerous traits with the incipient Alaka Phase ware and the more recent Hosororo ceramics in Guyana. These include temper, pointed bases and firing mode that yielded a light yellowish brown color. These ceramics may have cultural links with the Mina or Salgado ceramics (Gaspar and Imazio da Silveira 2000; Roosevelt 1995; Williams 1992: 243; 2003: 251, table P). Next to the well-known Alaka Phase ceramics, another known Early Ceramic Age site in the Guianas is Kaurikreek (2400–1600 BC), situated at a distance of c.10 km from Apoera on the river terrace of the Middle Courantyne River in western Suriname, bearing a ‘distinctive kind of pottery’ (Versteeg 1978).¹³ The so-called decorative “fretwork” appears to be absent in the eastern Guianas and is related to the Early Saladoid ceramics of La Gruta or Ronquin (Versteeg 1978: 18–26), given that Rouse compared this material to the inferior levels of the Ronquin site and confirmed the possible link (Versteeg 2003: 83).¹⁴ Interestingly, a short visit in August 2012 by the first author to the *Zorg en Hoop* depot in Paramaribo enabled him to observe striking similarities between the paste and the firing color (yellowish-white) of the Kaurikreek material (e.g. Versteeg 2003: 85, fig. 5.16) and the Phase 1 ceramics of Saint-Louis.¹⁵ It should also be stated here that Kaurikreek is also a multi-component black earth site, because Versteeg noted that ‘the results of the radiocarbon dates do not correspond necessarily with the type of ceramics depicted in the article’ (Versteeg 1978: 18).¹⁶

More recently, the late Neil Whitehead and George Simon carried out research on both the (anthropogenic?) hills of the Wironie Creek as well as on the Nassau and Canje savannahs on the Lower Berbice River in eastern Guyana. For the first time since the discovery of the Kaurikreek site, they came across similar fretwork or *appliqué* decorated ceramics at Dubulay

Hill (Whitehead et al. 2010: 102, figs. 10, 11). The charcoal samples taken from the lower layers of their test pit at *c.*2 m below the surface, yielded a first date of 3000 BC (Ibid. 96). These mounds may possibly be multi-component sites which certainly require detailed (micro-)stratigraphic research (cf. Versteeg 2003: 94).

In general, the initial Guiana and Pará pottery can be considered fairly crude compared to the earliest ceramics found in northern Colombia (Oyuela-Caycedo 1995, 2006; Raymond et al. 1998; Reichel-Dolmatoff 1965), the Orinoco River (Roosevelt 1980; Rouse and Cruxent 1963) and the Amazon River near Santarém (Gomes 2011).¹⁷ The latter ceramics were already of fairly good quality and featured sophisticated decoration when compared to the ceramics found along the Atlantic coast of the Guianas or the Lower Amazon. The earliest ceramics excavated at La Gruta and Ronquin have been attributed to the Saladoid subseries of the Middle Orinoco River. They exhibit white-on-red painting, zoomorphic adornos and incisions on the vessel rims (Cruxent and Rouse 1958, 1959). La Gruta ceramics date back to *c.*2100 BC whereas Ronquin ceramics are dated between 1600 and 1100 BC (Roosevelt 1980: 195); however, it is also believed that the early Orinocan sites are in need of further research and excavation (Barse 2009; Oliver 2014) since the latter sites do not provide crude, experimental ware such as the Alaka or Mina wares. In fact, the Middle Orinocan high-quality wares are decorated elaborately and may be dated more recently as suggested by Barse (2000, 2009). Moreover, the initial French Guiana ceramics correspond better with the early, grit-tempered La Gruta phase dated between 2500 and 1600 BC (Roosevelt 1997: 90). Finally, whether all the early ceramic sites in northern South America represent unique cultural “islands” or whether they belong to one and the same initial Ceramic Age Horizon is difficult to conclude at present; the latter option does however seem unlikely as the quality of the ceramics is quite different (cf. Neves 2008).

At first sight, the French Guiana sites also exhibit some differences from their Venezuelan, Guyana and Brazilian counterparts. These include the absence of shell middens or *sambaquis* and the abundant presence of oven pits at Eva 2 and Plateau des Mines. It can be argued that these differences arise from preservation and methodological issues. The former absence may be explained by the high acidity in most French Guiana soils, making shell preservation very unlikely. The latter difference can be related to differences in scale and methodology of archaeological research between both regions. The French Guiana sites, notably Eva 2, Saint-Louis and to a lesser extent the Plateau des Mines, have been excavated extensively due to compliance archaeology, revealing many features and their spatial distribution. In general, it can be stated that archaeological research in the other regions was smaller in scale and primarily focused on shell middens, thereby largely ignoring the surroundings of these shell middens, where the activity areas with cooking pits could have been situated.

These shell mounds are small conical mounds that vary in size but can measure 80 m $\times$ 30 m $\times$ 1.5 m. Excavation was often limited to only a few square meters. The middens consist of shell, shell fish, bone, lithic debris, stone tools, fire-cracked rocks and an occasional burial. These middens reflect the exploitation of the mangrove swamps and estuaries where subsistence was based on shellfish gathering, hunting of animals and the collection of wild vegetable foods. If shell mounds were present at the French Guiana sites, their presence would have complemented the layout of the sites, probably permitting demarcations of activity and waste areas.

Conclusion

As suggested in the introduction, recent large scale archaeological work at the Eva 2 and Saint-Louis sites in French Guiana have revealed some important new data on the transition from the Late Archaic Age towards the Early Ceramic Age (the Formative Period). Both sites yielded a typical set of features, lithic food processing implements and crude early ceramics. Based on starch grain analysis and ethnographic analogies in the Amazon and North America, it is hypothesized in this chapter that edible plants were processed by means of grating, grinding and cooking in order to produce pastes or balls, initially in oven pits and later in ceramic vessels.

The large quantity and spatial distribution of clustered oven pits at Eva 2 perhaps reveal a migratory cycle spanning many centuries creating persistent places and reflecting an important base of subsistence activities which eventually evolved into a more sedentary way of life. The changing agricultural developments during the Early Ceramic Age also required more innovative ways of food processing. This first favored the replacement of cooking pits by the usage of ceramic pots. Alongside the use of these ceramic containers for cooking of maize, sweet potato and arrowroot, we observe the first evidence of pit burials (with complete ceramics). Based on the archaeological work presented in this chapter, the earliest dates for ceramics in French Guiana can now be placed in the latter half of the third millennium BC. The absence of clay griddles for this period indicates that tubers and maize were perhaps not consumed as flatbreads but rather as mashed masses (e.g. *tamales*), thick soups or stews. The introduction of these clay griddles points to a second shift in food processing of starchy foods. It shows a change towards the baking of tortillas or cakes made of maize and/or manioc flour and this forms the final change towards a manner of food processing that lasted the rest of the Ceramic Age.

The early presence of domesticated plants and sweet potato at Eva 2 may have represented a catalyst for these cultural changes. These changes marked an early innovative phase in the subsistence economy and set the stage for the later development of the Ceramic Age, starting around the second half of the second millennium BC, and possibly in the first millennium BC (i.e. Phase 2 of Saint-Louis) (van den Bel 2012, 2015a).

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Notes

- 1 It may be evident that domestication and agricultural development in tropical regions differ drastically from other classic Neolithic contexts, i.e. European cereal-based agriculture. It must be stated here that the outline of this contribution is based on the recently published PhD dissertation of the first author at *Sidestone Press* in 2015. As a matter of fact, the recent critique expressed by Roosevelt (2016: 19) regarding the Eva 2 site (French Guiana) in a paper on the early farming in Northern South America is just unfounded and deplored by the first author. She negatively emphasized certain excavation techniques commonly used in compliance archaeology, but also dangerously took isolated data in order to minimize the importance of this research. She was kindly invited to the Inrap archaeological base in Cayenne in 2006, just after the excavations, and on that occasion she was totally excited by the discovery and revelations of this site when we shared with her our data. Thus, rejecting new robust data produced by groundbreaking and collaborative research, by virtue of her opinions based in some upgraded personal and less recent research is, to my opinion, an unfortunate and unethical way for initiating a high-quality discussion.
- 2 More recently another Archaic site featuring rock-clusters has been found a few kilometers to the east of Eva 2 yielding similar characteristics (Briand 2015).
- 3 The origins and chronology of the White Sand Formation of the Guianas is still shrouded in mystery (Blancaneaux et al. 1973; Boyé 1963; de Boer 1972; Palvadeau 1999; Wong et al. 1998). The archaeological occupations found in French Guiana at approximately 1 m in depth within this formation may contribute to solve this geological problem since ancient human presence in a stratigraphic position was hitherto unknown for this formation.
- 4 For the history of salvage and public (compliance and/or commercial) archaeology in France, see Jean-Paul Demoule and Landes (2009).
- 5 The second Early Ceramic Age occupation or Phase 2 of Saint-Louis is characterized by different ceramic material, a distinct lithic industry but also by the presence of dark earth or *terra preta* (Brancier et al. 2014; Knippenberg 2012; Pagán Jiménez 2012; van den Bel 2012; van den Bel et al. 2011).
- 6 It is believed that heavily sand-tempered ceramics are often related to a better performance of cooking pots, thanks to the conduction of heat (Skibo and Schiffer 1995: 83).
- 7 Jaime Pagán Jiménez would like to add that edge grinders served to process raw vegetables such as maize, beans, and other seeds. They were probably also applied during a second or third stage of processing tubers and rhizomes, for example after the tubers had been grated. This may well be the case in the Greater Antilles with the *Zamia* sp. processing. Ethnographic and ethnohistoric documentation informs us that first the tuberous stem is peeled. Next, the organs are placed to rest and dry until the resins have disappeared. The tuberous stems are grated. Finally, the substance is placed in the sun to dry (and for passing the larvae which functions as the eradicator agent of the toxic compound). Subsequently, the dry and larvae infested substance is ground.

- 8 Interestingly arrowroot, or *oeroewa*, is also consumed among the historic Warekulé or Akurio, a foraging group in southern Suriname, as recorded by Lodewijk Schmidt in 1941 (Findlay 2011: 45).
- 9 Boomert (2000: 83) also refers to the processing of maguey, i.e. wild agave heart (*Agave cantala*) with manos after being roasted 'for 1–5 days on hot stones in pits.' This is related to the Manicuaran subseries which developed from Late El Conchero (Sanoja Obediente and Vargas-Arenas 1983).
- 10 For experimental research, see Pargeter et al. (2016). From an (ethno) historic point of view, the present author suggested that modern, rectangular grater boards inserted with pyramidal rock chips are possibly Amerindian copies of iron and/or copper graters which have been traded in the Guianas by the Europeans since the early 17th century (van den Bel 2015b).
- 11 The ECA site of Kaurikreek did feature griddles (Versteeg 1985: 658). However, their attribution to this early occupation is unclear.
- 12 For further reading on these tools, see Barse (1995: 110).
- 13 This black earth site is probably a multi-component site as Aad Versteeg evokes in a footnote. In fact, the results of the radiocarbon dates do not correspond necessarily with the type of ceramics depicted in the article.
- 14 Versteeg obtained this affiliation through personal communication with Rouse. Fretwork decorated ceramics were also discovered at the Orealla site, just above the tidal reach of the Corentyne River (Williams 2003: 341, fig. 3.48g, h). Only one date was obtained for this site (Beta-20008, 1080 ± 60 BP). However, it may well be the case that it is a multi-component site, too, because it includes, for example, hyperboloid bowls (ibid., fig. 4.68.8, 9).
- 15 No complete vessel shapes were detected in the Kaurikreek boxes (N=2) when the first author visited the Zorg en Hoop depot. However, small rounded bases were observed that resembled those of Saint-Louis.
- 16 Two samples were taken from the same test pit, one at a depth of 55–60 cm and a second one at 44–60 cm (below the surface). These yielded dates of respectively 3620 ± 160 BP (GrN-10303) and 2530 ± 30 BP (GrN-10875). Calibrated at 2σ , these fall between 2400 and 1600 BC for the first and between 800 and 500 BC for the second (Versteeg 1985: 658). Versteeg favors the earliest date because this sample consisted of one charcoal fragment whereas the other consisted of various charcoal particles collected from the same particular archaeological layer (Versteeg and Bubberman 1992: 25, 59).
- 17 Meggers (2011: 149–150) believes there is a link between Valdivia, San Jacinto, and a possible later phase of Taperinha. She also states that the Caribbean coast of Colombia is probably the most likely place of origin (?) of the earliest ceramics from this Age.

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Postscript

Peter Bellwood

I am grateful to Basil Reid for inviting this final contribution, especially since I am not an authority on Caribbean archaeology. However, I have long had an interest in three topics that bulk very large in the archaeology of the Caribbean Islands – the inception of food production, human migration and the rise of complex societies. In this short concluding chapter, I discuss these three topics from a comparative perspective.

Food production

The inception of food production in the Caribbean and adjacent regions is clearly a major focus of this book, as was made clear in the introductory chapter. This is an enthusiastic book, alive with a sense of new paradigm. The central theme of the new paradigm is that ancient human subsistence economies can be visualized within three basic categories – foragers, agriculturalists/pastoralists and the varying mixtures of food production and hunting-gathering that lie in-between. This third mixed category, brought to life by Smith (2001) as “low-level food production,” is now gaining a life of its own. New evidence is presented in this book that it existed in many so-called Archaic sites in the Caribbean, inhabited before the arrival during the first millennium BC of Saladoid populations from northern South America, the people long regarded as the first fully fledged agriculturalists in the region.

A question therefore arises. What does it mean when microscopic traces of plant foods such as maize, manioc and sweet potato, already domesticated in distant Mesoamerican or northern South American source regions, turn up in Caribbean archaeological sites previously thought to have been occupied at this time purely by Archaic hunters and gatherers? Presumably, one cannot claim the Caribbean as a region of completely independent agricultural development because of this factor of external introduction for such major species, even if some local wild plants were domesticated as well. We also have the problem posed by the arrival of Saladoid material culture with agriculture and presumably Arawak languages during the first millennium BC. If Archaic populations had developed a fully sedentary lifestyle with reliance on food production before that arrival, then we must ask why their direct

descendants did not continue to dominate the Caribbean cultural landscape until the arrival of the Spanish. The evidence seems to suggest a partial rather than complete adoption of food production during the Archaic.

Partial adoptions of food production are always rather puzzling, unless the adopters lived in environments that were poor for farming but rich for foraging. Certainly, such environments have always existed, and as far as low-level food production is concerned this might be a key factor. From my perspective, however, identifying domesticated plants in Archaic contexts formerly presumed to lack such remains need not overwhelm the basic observation that prehistoric economies everywhere varied greatly in their capacities to support increasing human population sizes and densities, hence to fuel spreads of population, language and material culture into new regions (Bellwood 2009). For me, this is a fundamental point that applies to the Caribbean as much as to anywhere else.

At European contact, it is my understanding that the inhabitants of most of the Caribbean Islands (excluding perhaps western Cuba) were not the direct descendants of in situ Archaic forebears, but of Arawak-speaking Saladoid farming immigrants. These were thus the people who developed the farming systems that sustained the Taino. Even though I can detect in the chapters of this book some underlying rumbles of disagreement with the old migration-happy guard, best represented for an outsider like me by Rouse's (1992) book *The Tainos*, I suspect that most Caribbean archaeologists still agree that a Saladoid farmer immigration actually happened and is not just a figment of the imagination.

So, in the light of these new data, what really did happen in the Caribbean during the 7,000 years or so between the first human settlers and the conquistadors? As a non-specialist in this region I avoid comment on specific chapters, situations and sets of data. Neither do I claim expertise in the fields of stable isotope, starch and phytolith analysis that bulk so large in this book. I must assume that all claims made for domesticated plants in multiple Archaic sites are correct in terms of context, botanical identification and date – if they are not, then we are back to square one, or Rouse (1992). I am happy to agree that all is correct since it gives me a chance to debate certain issues, and I like well-reasoned debate. The editors and contributors clearly have quite strong views about issues such as foraging versus farming, low-level food production versus agricultural dependence, and that rather thorny concept called “migration.” There is also debate about the recognition of complexity in socio-political organization. I have opinions on these matters too, so let us head further into the fray.

Foraging versus farming, low-level food production versus agricultural dependence

The issue of foraging versus farming emerges in several chapters, sometimes with the implication that neither ever really existed in prehistory as a separate

behavioral type and that all ancient economies lay somewhere within a continuum between the two. I am inclined to agree, but need this mean that foraging and farming are no longer viable concepts at all? Does the totality of post-LGM subsistence economic evolution amongst humanity just collapse into an indivisible blur?

I am dubious about this, partly because for me, the annual round of activities associated with mobile foraging has to be fundamentally different from the annual round of activities associated with permanent field agriculture. Of course, farmers can hunt and foragers can manage resources – there is nothing new in such an observation and it is supported by a plethora of ethnographic data. But I have always regarded an increasing tendency to rely on food production as a significant variable in all discussions of human socio-cultural history and evolution (Bellwood 2005, 2009), even if many farmers do/did hunt and gather occasionally. Amongst the ancient peoples discussed in this book, the Mesoamerican Maya (and especially the people of the wonderfully preserved site of Ceren), the creators of raised fields and *terra preta* soils in parts of the Caribbean and northern South America, the pottery-using Caribbean Saladoids, and their Taino successors as described in ethnohistoric Spanish accounts (Wilson 1990) were all farmers to a fairly specialized degree. Low-level food production might often have existed in specific situations, but it was not universal.

Furthermore, many of the ethnographic and modern populations whom I would classify as low-level food producers in Smith's (2001) terms inhabit terrains that are not favorable for intensive food production, perhaps poor for farming but rich for foraging as discussed earlier. As examples in a region well known to me, many regions of Indonesia and the Philippines have soils and equatorial climates unsuited to extensive cereal (especially rice) production (Geertz 1963). Their inhabitants often rely on non-cereal crops with shifting cultivation and low population densities. Many still hunt, fish and gather. Another more ancient class of low-level food producer appears in the archaeological record during those millennia between the pre-domestication cultivation of wild resources and eventual dependence on fully domesticated resources, as in Neolithic Western Asia and China (Bellwood 2013).

The general tendency within the more fertile agricultural latitudes of the world has thus been for such low-level food producers either to develop themselves into more dedicated food producers with time, or to fuse with some of the latter due to varying processes of immigration and admixture. It appears that the latter might have been the case with the Archaic to Saladoid shift in the Caribbean. From my perspective, therefore, the Archaic populations of the Caribbean who had access to crop plants such as maize, sweet potato and manioc can indeed be visualized as foragers with low-level farming, or low-level farmers with foraging (as one wishes), eventually becoming blended around 2,500 years ago into a more productive Saladoid pattern of food production.

There is, of course, yet another question. Were the Archaic populations of the Caribbean *really* involved in food production, even on a low level, or do the identified crops simply reflect periodic exchange between mainland farmers and island foragers, with farmers giving foragers cultivated food in return for wild products? The latter is quite possible since Caribbean Archaic populations were contemporary with proven food producing populations in other tropical regions of the Americas. However, the great distances involved in crop transference, especially if the farmers lived on the American mainland, give cause for doubt, unless some of those farmers were already established in the Caribbean Islands before 4,000 years ago. It seems most likely that the crop remains found in the island sites were from plants actually grown in those locations.

A very early establishment of mainland farmers in the islands, several millennia before the Saladoid, may be given proxy support by a new statistical analysis of the density of radiocarbon dates through time for the South American mainland. This has identified a threefold population increase between 5500 and 2000 BP, related by the authors to an increasing reliance on domesticated resources, especially plant foods (Goldberg et al. 2016). One wonders if this agriculturally induced increase in population numbers in northern South America led to periodic transfers of crops with small numbers of immigrants into the Caribbean islands, two or more millennia prior to the main Saladoid dispersal. Perhaps it did, but unfortunately the analysts did not consider Caribbean radiocarbon dates. However, Fitzpatrick's (2015) table of radiocarbon dates for initial settlement of Caribbean islands lists 23 out of a total of 39 islands as first settled only in the Ceramic Age, after 800 BC. This rather negatively suggests that the Saladoid must still be considered as a major episode of island colonization.

I also wonder about the role of maize in the Caribbean Archaic, following Kruger's affirmation in this volume that it did not become productive as a cob until around 3,000 years ago, and that earlier usage of this plant could have been as a source of sweet liquid fermented as a beverage (Smalley and Blake 2003). Maize beer as a staple food in Archaic subsistence is hard to visualize, but maize beer as a source of a good party or heady ritual is another matter altogether. Given the suggestion by Wang et al. (2016) that barley was introduced to Yellow River Neolithic China around 5,000 years ago as a major ingredient in fermented beer, this explanation for the arrival of early maize in the Caribbean Islands holds promise.

Saladoid migrations?

The opposition between the indigenous and the exogenous in explanatory terms bulks very large in discussions about the so-called "Saladoid," which brought in new types of artifacts to many Caribbean Islands, as well as a much greater reliance on agriculture, roughly between 800 and 500 BC (Keegan 2015; Leppard 2014; Reid 2009). The Saladoid did not bring in the first pottery

and ground stone artifacts to Caribbean islands, since examples of these occur in Archaic contexts, especially in Trinidad, as we find also in comparable pre-Neolithic sites in southern China and mainland Southeast Asia (Bellwood 2015). Pottery, ground stone and agriculture no longer form an exclusive package in many regions of the world. Indeed, they have never done so, given the long-known existence of undoubted pottery amongst undoubted foragers such as the Andamanese and the Alaskan Eskimos, not to mention the early phases of the Jomon in Japan.

It is widely accepted that the Saladoid population became established first in Puerto Rico and the Lesser Antilles, with their later extensions westwards to Hispaniola and eastern Cuba involving admixture with Archaic populations (Fitzpatrick 2015; Reid 2009; Rouse 1992). It also seems reasonable to assume that the Saladoid archaeological expression was associated with the arrival of Arawak languages in the Caribbean islands, ancestral to the Taino languages as spoken in AD 1492 in all but the western part of Cuba – Arawak being a language family of Amazonian origin (Aikhenvald 2015; Heckenberger 2015). I am a non-believer in the power of language shift as a significant driver of language family spread on the very large geographical scale of the Arawak family (Bellwood 2013), especially amongst non-state and non-literate societies. Therefore, I see no source for Arawak languages in the Caribbean other than through a substantial degree of population movement, of course with consequent admixture between newcomers and resident Archaic populations. Otherwise, we have to identify a reason for an archipelago-wide process of language shift, and I certainly cannot visualize one.

None of the chapters in this volume discusses linguistic research, and ancient DNA from Saladoid or Taino sources appears to be restricted to mtDNA (Fitzpatrick 2015: 322–324) and still inconclusive about precise questions of ancestry. Despite this, none of the authors demands expulsion of the Saladoid migration concept from Caribbean archaeology. I have never read any convincing arguments for such an expulsion, despite the general unpopularity of migration amongst archaeological communities at the present time. To me, it still has great explanatory value in understanding the course of Caribbean prehistory.

Pre-Saladoid migrations

Before we leave the topic of migration, there is another issue to consider. Sizes and distances from other land usually feature heavily in discussions about the nature of islands (Keegan and Diamond 1987). From my perspective as a specialist in Island Southeast Asian and Oceanic archaeology, the Caribbean Islands are difficult to compare with those in the Pacific proper owing to vast differences in scale. Better perhaps than a broad Pacific comparison would be one with the oceanic (non-continental) islands of Wallacea (eastern Indonesia) located between the Sunda and Sahul continental shelves (Bellwood 2017: fig. 2.2). The Greater Antilles would thus equate with

Sulawesi, quite close to the Sunda continent yet always separated by sea passages. The Lesser Antilles would equate well with the Moluccas or Nusa Tenggara (Lesser Sundas from Lombok to Timor) in being a chain of mostly invisible small islands, yet invisible from the larger adjacent land masses (except for Bali to Lombok) during the Holocene stage of high sea level (Torres and Ramos 2008).

Given these Wallacean parallels, one observation about human colonization that will immediately strike a Southeast Asian archaeologist is that the current initial settlement date of 7000–6000 BP for the Caribbean Islands (Fitzpatrick 2015; Keegan 2015) means that First Americans took almost 10,000 years to reach Cuba and Hispaniola, with apparently another 4,500 years required to reach Jamaica and the Bahamas, and the Cayman Islands not until European arrival. This is assuming an archaeological and genomic settlement from Siberia via Alaska around 16 kya (Llamas et al. 2016; Meltzer 2015) and that First American sites (Clovis era and before) dating from around this time are not hiding incognito beneath the ground surfaces of Cuba or Hispaniola.

Why so long, given that the Wallacean islands were apparently settled quite close to the genomic and archaeological date for first human settlement of Australia and New Guinea, that is around 50 kya? One might wonder just how good were First American maritime navigational capabilities at 16 kya? No one can deny a presence of some kind of water crossing capability amongst early modern humans, given that people reached Australia much earlier than Alaska. But the same issue arises with First Australians – how good were they at surviving on the open sea out of sight of land?

This is actually quite an interesting question with potential implications for the early migration of *Homo sapiens* from Africa. The widely accepted archaeological date of 50–48 kya, or perhaps even 65 kya, for the *sapiens* settlement of Australia and New Guinea (Allen and O’Connell 2014; Clarkson et al. 2017) is taken by many geneticists who use molecular clock timescales to fall fairly close to the date of initial *Homo sapiens* migration out of Africa (Nagle et al. 2015; Stoneking and Harvati 2015). However, with anatomically modern human teeth claimed to date as old as 100 kya in China and Java (Liu et al. 2015; Storm and de Vos 2006), are the molecular clocks giving us the right answer? I make no strong claims here and merely wish to raise the issue for debate.

But one must ask, using the Caribbean parallel, if modern humans could have existed in Southeast Asia for tens of millennia before the opportunity arose to float or paddle across the numerous sea passages of Wallacea, sometimes out of sight of land, with enough people (especially women) to establish long lasting populations in Sulawesi, New Guinea and Australia? Were ancestral *sapiens* populations already present in eastern mainland Asia tens of thousands of years before 50 kya, as sometimes suggested in light of the last interglacial Skhul and Qafzeh populations in Israel (Reyes-Centeno 2016)? Comparison on this scale can raise interesting possibilities.

On complex societies and widespread connections

Because of their tragic early colonial history, associated with disease introduction by the Spanish, drastic population decline, dispossession of land, forced labor and language extinction (at least in the case of Arawak languages within the Caribbean islands themselves), the Caribbean islands do not have the rich ethnographic landscape of indigenous peoples that we still find in the Austronesian and Papuan worlds of Island Southeast Asia and Oceania. Although Wilson (1990) and others have extracted much of what can be extracted from contemporary Spanish records, reconstruction of the nature of pre-European Caribbean society to a level of detail similar to that reconstructed by Kirch and Green (2001) for Ancestral Polynesian Society, using a range of ethnographic and linguistic as well as archaeological data, is simply not possible.

However, if one broadens the debate to include comparative linguistic data, especially on the very widespread Arawak-speaking societies of the Amazon and Orinoco Basins, then there are broad observations that one might apply to the Taino. For instance, Heckenberger (2015) summarizes a broad comparative literature to suggest that traditional Arawak speaking societies developed wetland management for agriculture, recognized birth order from founding ancestors in ranking, practiced status rivalry with a circulation of prestige goods and carried out formalized trade and rituals. Generalizations perhaps, but at least they put us within range of a general social model, one which I personally find remarkably similar to that for ancient Polynesian societies, although also one which perhaps applied to some degree to chiefdom societies all over the late pre-colonial world.

Also associated with issues of complexity are those popular topics of culture contact, integration and interaction. Any meaningful discussion of them in the Caribbean context must take account of island intervisibility (Torres and Ramos 2008) as well as navigational ability, given the ethnographic absence of sails and outriggers on Caribbean watercraft. The Caribbean islands as a whole were not visible from surrounding mainlands, and the Greater Antilles were not visible from the northern end of the Lesser Antilles, or vice-versa. So serious contact meant paddling out of sight of land in these situations, at least for a while.

One such potentially remarkable situation where ocean crossing could have been very important concerns the movement of Motagua jadeite axes from Guatemala to sites in Antigua. Should this identification hold up to scrutiny (Harlow et al. 2006; and see discussion in Fitzpatrick 2015: 320), then an across-water movement of this raw material up to 3,000 km is attested. Did people really paddle with jadeite in a canoe all that way? Or did the jadeite somehow travel from group to group by land? If by sea, were ancient voyagers in the Caribbean aided by large flocks of homing birds? Or did early settlers extirpate such bird species, as in the Pacific (Steadman 2006)? I was intrigued to find that Fitzpatrick and Keegan's (2007) survey

of animal extinctions in the Caribbean Islands did not really address the issue of birds. Maybe little is known, but yet again, broad perspectives of this type can lead to interesting questions.

Where next?

We see in this book how new technologies, for instance in the recovery of phytoliths and starch grains from sediments and the working parts of stone tools, together with stable isotope analysis of bone, can bring to light new sources of information about ancient diets and introduce new perspectives on the past. But the surface of the earth still hides many secrets. In this regard I have a final question. How do tropical island landscapes affect the visibility of lowland and coastal agricultural sites where forest clearance has led to great depths of alluvial or colluvial burial (e.g. Bellwood et al. 2008 for the Philippines)? One millennium in a coastal or valley-bottom landscape in Island Southeast Asia can equate with two meters or more of overlying sediment, making a site visible to a developer with a bulldozer (if the bulldozer is stopped for long enough to inspect), but not to an archaeologist armed with a trowel. Many such sites are also deeply waterlogged, hence difficult to investigate using ground-penetrating radar techniques.

Put another way, what do we really know about the whole universe of tropical landscape Caribbean archaeology, both Archaic and later? What hidden surprises, including the possibility of sedentary settlements of Archaic date, might still await us if we can penetrate sufficiently far below the surface of the ground? I wish all Caribbean archaeologists the best of luck in finding out.

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Glossary Terms

Abrader Tool used to wear, polish or smooth other materials.

Active alluvial valleys Valleys created by the deposition of soil or sediments continuously or seasonally transported and re-shaped by water.

Aguada A modern-day pond in the **Maya Lowlands** that may have a natural, karst-process origin, but which is often situated in ancient human-constructed reservoirs.

AMS radiocarbon dating While conventional radiocarbon dating measures residual ^{14}C indirectly, Accelerator Mass Spectrometry (AMS) measures residual ^{14}C directly, thereby providing greater precision and requiring smaller sample size.

Anaerobic Relating to, involving or requiring an absence of free oxygen.

Anno Domini (Latin: “In the year of (our) Lord”), shortened to AD or A.D., is used to refer to the years after the birth of Jesus. A.D. or AD is also a shortening for Christian Era. Usually, AD comes before the year but comes after a century or millennium.

Anthracologist A scientist who analyses and identifies archaeological charcoal based on the principles of wood anatomy.

Anthropic soil Soil types whose physical and chemical properties, including parent material, are, or have been, regulated by human activities.

Anthropogenic Caused, produced or influenced by humans.

Anthropogenic fires Human-mediated alteration of the landscape through the burning of vegetation.

Anthropogenic landscapes Human-modified landscapes, ranging from small forest clearings for a camp or village to garden plots to massive earthworks to post-industrial urban centers.

Aquapelago As coined by Hayward, entities created when humans occupy and interact with integrated island and aquatic spaces, and which do not exist without human presence and human connectivities of island-water spaces. The term was introduced by Hayward to address the way in which human experiences integrate islands and their adjacent waters and seafloors, constituting a contextualized social unit.

Araquinoid A cultural tradition, mainly characterized by pottery styles, that occupied the Orinoco Valley, the Venezuelan Llanos and the Guianas coast between ca. AD 650 and 1400. Araquinoid people built extensive raised fields in flooded areas.

Arboriculture The cultivation and management of tree crops, shrubs and vines, as well as other woody plants. Can include cultural techniques such as selection, planting, fertilization, pest control, pruning, etc.

Archaic Age/Period A period of human cultural development in the Americas, generally defined to include the hunter-gatherer societies of the Holocene. It is preceded by the Paleoindian period, and ends with the development of intensive agriculture and settled villages.

Archaic (Maya Lowlands) Cultural time period in the Maya Lowlands corresponding to 7000 to 2200 BC.

Austronesian languages Languages associated with the expansion of the Neolithic Lapita culture after about 3,400 years ago, with links to languages spoken in Island Southeast Asia.

Bajo A clay-floored closed karst depression in the **Maya Lowlands** typically occupied by seasonal wetland ecosystems.

Banwarian and Ortoiran Subseries of the Banwarioid or Ortoiroid series, respectively. Both terms have been used to describe Archaic Age archaeological materials from Trinidad, the Northern Lesser Antilles and Puerto Rico.

Before Christ Shortened to BC or B.C., is used in the English language to refer to all years before the start of the time period *Anno Domini*.

Before Present Shortened to BP, the Before Present years is a time scale used in archaeology and other scientific disciplines to specify when events occurred in the past. Because the “present” time changes, standard practice is to use 1 January 1950 as the commencement date of the age scale, reflecting the fact that radiocarbon dating became practical in the 1950s.

Biodiversity Contraction of the words “biological diversity,” referring to the variability and variety of life on earth.

Biotope Ecological zone home to a particular assemblage of plants and animals.

Bipolar flakes Flakes produced by bipolar flaking technique, consisting of the placement of a lithic nucleus on an anvil to be struck with a hammerstone.

Bone collagen The major fibrous protein of bone, comprising 90% of the total protein in bone. When preserved in archaeological bone it can be used to reconstruct the source(s) of dietary protein.

Broad-spectrum subsistence adaptation Survival strategy based on the collection and/or production of a diverse range of food resources.

C₃ and C₄ plants Terms that refer to differing photosynthesis pathways in plants, a result of adaptation to different environmental zones. C₄ plants, such as maize, are better adapted to drought and high temperatures. Because of pronounced isotopic differences, stable isotope analysis can

detect whether an organism (such as *Homo sapiens*) consumed C₃ and C₄ plants during its lifetime.

Calibrated radiocarbon date A specimen's age after the direct results of radiocarbon dating have been converted to a calendrical scale.

Cemí Native term referring to a numinous, driving or vital force that can become imbued or manifested as spiritual beings and dead ancestors, in objects including those made out of wood, stone, human bone, and as natural phenomena such as winds and rain

Charcoal-burning clamps A domed pile of wooden logs arranged in a circle with a small chimney vent to allow burning. The log pile is completely covered with earth and straw to exclude air, before burning fuel is placed into the chimney to convert the logs very slowly to charcoal over a period of five days.

Charged areas Effect seen during scanning electron microscopy, wherein the poor electrical conductivity of the sample causes a build-up of negative charge.

Chipped lithic artifacts Tools made by percussion knapping of stone material (e.g. chert).

Chronometric data Data ordered on a time-scale through the determination of calendrical dates.

Classic Period (Maya) Cultural time period in Lowland Maya Civilization corresponding to AD 250 to 900; typically subdivided into Early Classic (AD 250–550), Late Classic (AD 550–770) and Terminal Classic (AD 770–900).

Columbian Exchange As first described by the historian Alfred Crosby, the transfer of plants, animals, insects and pathogens between the Old and New Worlds.

Columella Column-shaped pillar axis at center of snail (gastropod) shells.

Commensal A relationship between two organisms in which one organism typically benefits more than the other.

Conical manos Ground stone tool with conical shape used with a mealing stone to grind food or other materials.

Conucos The Taíno name for agricultural fields. Conucos also refer to the strategy of planting different staples in the same field (i.e. not monoculture). Usually associated with slash-and-burn garden plots.

Coppicing A traditional method of cyclical woodland management in which young tree stems are frequently cut down to near ground level, subsequently stimulating the growth of new brushwood.

Crosshatching Ceramic decoration technique consisting of incising intersecting sets of lines.

Cultivars Plant or group of plant species selected and propagated by humans.

Debitage or Débitage French term for the reduction of raw stone material. Also refers to the material byproduct of the process of lithic tool manufacture.

Dental calculus Also known as tartar, dental calculus is a layer of hardened plaque that forms on the teeth and can trap microscopic particles of food (**phytoliths** and starches). Analysis of dental calculus allows us to demonstrate the presence of particular foods in the diet.

Dietary protein signature Chemical/isotopic signature of various foodstuffs that can be detected by the analysis of bone collagen.

Disturbance indicators Features of a landscape that reveal perturbations of, or disruptions to, an ecosystem, whether by natural or human agency.

Domestication Human manipulation and treatment of wild organisms resulting in changes to organism reproduction and viability. Domestication can be intentional or unintentional.

Earth oven Also known as a ground oven or cooking pit, an earth oven is probably one of the simplest and most ancient cooking structures. It consists of a pit in the ground used to catch heat to bake, smoke or steam food, notably larger quantities of food. They are known all over the world and are still common practice in Polynesia.

Ecological niche construction The process by which a community or set of communities interacts with their physical environment by modifying it to their perceived benefit and adjusting to unforeseen consequences. Also referred to as **anthropogenesis**.

Edge-ground cobbles or edge grinders Also known as edge-cobbles. Grinding stones flattened by use in one of their margins.

Elevated Interior Region Karstic interior portion of the Yucatan Peninsula with elevation above 80 m amsl, with largely internal drainage and few year-round natural water sources.

Endemic Native or restricted to a defined geographic location.

Endemism The ecological state of a species being unique to a defined geographic location.

Estuarine environments Ecological zone affected by tides and characterized by the existence of a body of land-drained water mixed with seawater.

Ethnobiological Examining past and present dynamic relationships between peoples, plants, animals and environments.

Ethnobotany The field of study investigating human-plant interactions.

Farming The practice of cultivating the land or raising stock; production that relies essentially on the growth and nurturing of plants and animals, especially for food, usually with land as an important input; the science or process of cultivating the soil to produce plants and animals that will be useful to humans in some way.

Fixed-point mobility A term used in reference to the seasonal settlement strategy of mobile foraging communities, in which there is one location that is returned to year after year. An example of a fixed-point is a riverine estuary where foragers can exploit dependable marine resources at a particular time of the annual cycle.

Food-collecting adaptation Survival strategy based on the procurement of naturally occurring edible resources in the environment.

Food-producing adaptation Survival strategy based on the control, manipulation and propagation of edible resources

Forbs Herbaceous (non-woody), flowering, broadleaf plants that are not grasses, sedges or rushes.

Formative Period Term borrowed from the Andes where it refers to the **Pre-Classic** periods. The term is also used in the Amazonian Lowlands Guianas, notably by the late Denis Williams, referring to the Pre-Ceramic or Aceramic periods featuring polished tools, shell mounds as well as early horticulture of the Alaka Phase. In this case, it represents the final stage of the Archaic Age and has no relation to the **Pre-Classic** periods in the Andes.

Formative Period (Mesoamerica) A period of cultural development between the Archaic and Classic Ages/Periods of Mesoamerica, approximately 2000 BC to AD 200, marked by the introduction of ceramics, the development of fully agricultural societies, settled village-town-city life and social complexity. It is generally separated into the Early Formative (1800–1000 BC); Middle Formative (1000–400 BC); and Late Formative (400 BC to AD 200). Sometimes referred to as the **Pre-Classic** Period.

Freehand Stone tool manufacture technique consisting of striking a lithic nucleus with another tool or against a fixed stone in order to obtain flakes.

Geoarchaeology The application of knowledge and methods from sedimentology and geology to the understanding of archaeological processes, including taphonomy and site formation.

Glume A hard casing surrounding and protecting a seed.

Griddles Clay artefact with a flat surface used for cooking cassava (and other foods) in the circum-Caribbean.

Guianas A region delimited by the mouth of the Amazon to the east, by the Atlantic Ocean to the north, by the Amazon River to the south, and by the Rio Negro and the Casiquiare canal to the west.

Herbaceous Plants with non-woody stems.

Historical ecology A field of study or research program focused on collating disparate lines of evidence from anthropology, archaeology, history and paleoecology to help explain how humans have affected natural landscapes.

Holocene The geological epoch consisting of the last 11,700 years since the end of the Pleistocene or the last major glacial epoch.

Holocene Drought Based on lake records in lowland Amazonia, a major dry event that reached its peak between 7000 and 4000 cal BP. This phenomenon may have been linked with El Niño/Southern Oscillation.

Horticulture Small scale agriculture characterized by cultivation/use of a variety of plants.

Human niche construction A concept from evolutionary ecology, whereby organisms modify portions of an environment as part of their survival strategy

Hutia A moderately large rodent of the Capromyidae family that was endemic to certain of the Caribbean Islands (Greater Antilles and Bahamas). Hutia was an important source of animal protein on certain islands during prehistory.

Hydrophilic plants Plants adapted to wet environments.

Incidental domestication Differs from both specialized and agricultural domestication in that the relationship between humans and plants is played out within a non-agricultural environment. In other words, the relationship is not intentional.

Incipient agriculture A condition in which agriculture was/is part of a larger network of other food-procurement strategies such as collecting, fishing and hunting. Incipient agriculture is one of the defining characteristics of the Archaic Age in the New World.

Inter-group interactions Processes including – among others – human mobility and exchange (of goods and ideas) between different communities.

Isotopic Relating to isotope analysis or the distribution of certain isotopes within chemical compounds or molecules.

Joboid Pertaining to the Joboid series, a percussion lithic technology characteristic of Venezuelan earliest hunters.

Landscape All the visual and physical elements of a land surface area when they are observed, interpreted and re-defined by humans.

Landscape learning The process by which humans acquire knowledge about the physical and social environment, especially in the context of colonization of new places.

Lapita A cultural complex of the southwest Pacific associated with the expansion of the Austronesian languages, but incorporating elements, including plant domesticates, from previously-established cultural traditions.

Leaf-cutter ants Fungus-growing ants that cut pieces of leaves, flowers and other plant organs and bring them to the nest to feed a fungal symbiont, which the ants then consume. *Atta* and *Acromyrmex* species are major agricultural pests in many parts of the New World tropics. One species of *Acromyrmex* is among the soil organisms that, by their nest-building activities and movement of organic matter to nests, contribute to maintaining the vestiges of pre-Columbian raised fields in French Guiana.

Lithic core Stone nucleus from which one or more lithic flakes were detached during the lithic reduction process.

Localized niche A bounded area (such as a river estuary) where a community interacts with the physical environment to create a localized ecology.

Low-level food production Economic practices that include exploitation of domesticated species without dependence on them (see **Incipient agriculture**).

Management Human interactions with, and/or influence on, a wild organism or environment with the aim of increasing organism abundance and availability.

Marunguey A plant of the species *Zamia erosa* (previously known as *Zamia amblyphyllidia*) native to the Greater Antilles. In an unprocessed state, the roots of marunguey are poisonous, but with processing, they can be made edible.

Maya Lowlands The cultural region occupied by Lowland Maya civilization; the Yucatan Peninsula and contiguous low-lying areas today comprise the Mexican states of Yucatan, Campeche, Quintana Roo, northern and eastern Chiapas, and eastern Tabasco, as well as the entire country of Belize, the Peten District of Guatemala and portions of eastern Honduras and El Salvador. The Maya Lowlands is often divided into two cultural spheres, the Northern Lowlands and Southern Lowlands along a line running between Chetumal Bay on the east and the Laguna de Terminos on the west.

Mesic A habitat or environment characterized by moderate to high levels of moisture.

Microartifacts Artifacts or fragments of artifacts that are smaller than 4 mm. This type of evidence of human activity is so small that it is usually not removed from a site, even during sweeping, looting or tilling. Therefore, microartifacts are indicative of intensity of site use and of type of activities conducted on the site's surface.

Microtome Scientific equipment used to cut extremely thin slices of material, known as thin sections, which are examined by means of optical microscopy.

Midden sites Archaeological sites consisting of spreads and clusters of mollusc shells.

Milling stone A flat or concave piece of rock upon which plant tubers or seeds are ground.

Milpa A swidden or long (forest) to short (bush) fallow agricultural field in the **Maya Lowlands**.

Montones Taíno name for agricultural mounds. The Spanish described them as about 1 m in diameter and less than 1 m tall. It was reported that both manioc and sweet potatoes were grown in the mounds.

Monumental architecture The construction and use of large-scale monuments, buildings and other structures, typically involving the use of earthen mounds, landscape modification, and/or stone masonry.

Mortuary site A site of human burial and the rituals associated with it.

Mother-of-pearl (nacre) Inner shell layer produced by certain molluscs for their protection.

Neolithisation Process of societal transition from predatory or extractive subsistence practices to long-term food production based on plant and animal husbandry (see **Plant husbandry**).

Neotropics Area of the Americas located between the Tropics of Cancer and Capricorn (23.5°N and 23.5°S).

Nixtamalization A process of either soaking or boiling maize kernels in water containing ashes, lime or some other alkali substance. This breaks

down and releases important amino acids, aiding in the digestion of maize.

Olmec An early (1300–500 BC) complex culture that developed along the southern Gulf Coast of Mexico in the states of Veracruz and Tabasco.

Outgassing The release of a gas dissolved, trapped or absorbed in a material or substance.

Papuan languages Languages spoken in Papua New Guinea and neighboring islands, descendant of the earliest regional languages spoken more than 40,000 years ago.

Parenchyma A plant tissue consisting of thin-walled living photosynthetic or storage cells.

Pedogenic/pedogenesis Referring to processes of soil formation.

Pelagic fish Fish species whose predominant habitat is the open sea.

Petroglyph A human-made carved image on a relatively stationary rock surface (boulder, cave, rock formation, ball court) produced by pecking, grinding, abrading, scratching or other means; a type of rock art.

Phytocultural Relating to the dynamics between humans and plants.

Phytogeographical Describing the scientific study of the geographical distribution of plants and their habitats.

Phytoliths Microscopic inorganic silica bodies that form in the cell walls of plants; very often preserved in the archaeological record.

Pictograph A human-made painted image on a relatively stationary rock surface (boulder, cave, rock formation); type of rock art.

Pith flecks Minute spots or streaks in wood resulting from injury by the boring of small insects or larvae.

Plant husbandry The practice of domesticating crops.

Plant microfossils Preserved parts of plants that can only be observed through magnification.

Pleistocene The geological epoch that lasted from about 3 million to 11,700 years ago and which was marked by repeated glacial cycles.

Pollen Microscopic grains produced in the anther, or male portion, of flowering plants and dispersed for sexual reproduction.

Post-Classic (Maya) Cultural time period in Lowland Maya civilization corresponding to AD 900 to roughly AD 1500.

Postholes Holes dug in the ground to install posts.

Pre-Classic (Maya) Cultural time period in Lowland Maya civilization corresponding to 2200 BC to AD 250; typically subdivided into Early Pre-Classic (2200–1000 BC), Middle Pre-Classic (1000–400 BC), Late Pre-Classic (400 BC to AD 100), and Terminal Pre-Classic (AD 100–250).

Protocultivation Evolutionary stage in the transition from food collecting to food production. Sometimes referred to as incidental domestication.

Proxy evidence Data, which substitute for direct measurements, used to reconstruct climatic conditions that existed in earlier periods. This evidence consists of, among others, preserved physical characteristics of the environment (such as pollen, coral, charcoal, wood).

Queen conch Common name of the gastropod mollusc *Lobatus gigas* (formerly *Strombus* or *Eustrombus gigas*).

Raised fields Agricultural mounds of different sizes and shapes, often built in flooded plains, to cultivate crops above the water level. This technique was quite common in South America near the end of the pre-Columbian period.

Rejollada Karst sinkhole in the **Maya Lowlands** typically featuring deeper, more humid soils than surrounding areas.

Remote Oceania The islands south and east of the Solomon Islands archipelago, including Micronesia and Polynesia, settled by Neolithic populations after about 3,400 years ago.

Resource extraction Economic practices that do not include the exploitation of domesticated plant and/or animal species.

Resource patches Spatially discrete locations with relatively concentrated naturally occurring or culturally induced edible or technological resources.

Resource production Economic practices that include exploitation of domesticated plant and/or animal species, at any scale.

Rhizome A modified subterranean stem of a plant, often found underground, but also capable of sending out roots and shoots from its nodes (e.g. ginger).

Riffle box A riffle box is used to divide a sample into two equal parts, thus obtaining a representative sample.

Sambaquis A Tupian word for a shell midden or kitchen midden containing bone, sherds, lithics, botanical material and human excrement.

Scanning electron microscopy A microscopic technique that relies on the interaction between a focused beam of high-energy electrons and the surface of samples in order to produce signals that reveal information about morphology and structure. Through analyses of selected locations on the sample, qualitative or semi-quantitative determinations can be made about the sample's chemical composition.

Scintillator backscattered electron (BSE) detector BSE detectors are located in an SEM above the sample in order to collect electrons scattered as a function of sample composition. Scintillator BSE detectors have permitted the use of low accelerating voltages on fragile or beam-sensitive biological samples.

Sedentism Year-round residence at one location.

Siliceous plant Plants that create internal microscopic structures made of silica (see **Phytoliths**).

Slash-and-burn Economic practice that consists of cutting and burning plants to create the space and necessary conditions for cultivation.

Social agency An approach that argues that humans do not simply react passively to events, but actively engage with their social environments through practice.

Social memory Memories that are shared by an entire community, constructed by, and maintained through, collective practice and ritual.

Soil The upper layer of a sediment bed that has been affected by weathering and biotic processes, thus changing its chemical and physical characteristics. It consists of the parent sedimentary material mixed with organic matter, including living organisms.

Stable isotope analysis The use of measured ratios of heavy to light stable isotopes (isotopic composition) of an element in order to detect changes in organic and inorganic substances that can be directly linked to physiochemical reactions including hydrological, atmospheric, biological and lithological systems.

Starch grains Carbohydrates produced in different parts of certain plants to store energy.

Subsistence regime Economic strategy focused on providing water, food and shelter.

Symbiotic relationships Long-term interaction between two species or groups which create different relationships and dependencies between them.

Talus A sloping mass of rock debris or sediments at the base of a cliff.

Tamales A traditional Mesoamerican dish made of *masa* or dough (mainly made of maize), which is steamed in a folded leaf. However, references to the consumption of dough as tamales are known from the Lesser Antilles and the Guianas from historic documents.

Taphonomic Describing, or pertaining to, the processes that affect archaeological remains subsequent to burial.

Taxon (singular); Taxa (plural) The term “taxon” (singular) is used to describe a taxonomic unit of any group or rank in the biological system of classification, for example: a phylum, order, family, genus or species; the term “taxa” is used for the plural.

Tectonic Relating to the structure and properties of the earth’s crust and referring to the processes that cause movements of the crust.

Tethering Refers to material, social and/or ideational influences that encourage a community to favor a locale and/or landscape feature over others. See also **Fixed-point mobility**.

Teosinte Several wild varieties of *Zea mays* that grow in the semi-arid highlands of Mesoamerica. One variety, *Zea mays* ssp. *parviglumis*, is the ancestor of domesticated maize.

Terrace In the **Maya Lowlands**, a laid stone or rubble wall used to retain soil and create stable planting surfaces on sloping terrain. Forms include cross-channel check dams, contour terraces along slopes and foot-slope terraces at the base of steep hills.

Terra firme Interfluvial areas of the Amazonian rainforest which are not flooded during the wet season.

Terra preta Portuguese term meaning “black earth”. Terra preta and similar soils are classified by scientists as Anthropogenic Dark Earths (ADE), the products of long-term (continuous or discontinuous) human occupation in the same place. The excellent fertility of these soils is due to

- the presence of charcoal (from burning by humans) and of nutrients derived from organic material deposited during human occupation. The charcoal increases the soil's ability to retain nutrients against leaching.
- Territorial niche** A region relatively unconstrained by local physical conditions, within which a community with a mobile subsistence regime practices niche construction over a number of locales.
- Tesguino** A traditional Mesoamerican beer made from the juices of the maize stalk.
- Thomas Malthus** Late eighteenth/early nineteenth-century British scholar who argued that the intrinsic rate of human population growth is geometric while food production only increases arithmetically, eventually resulting in such population-control measures like elevated death rates (warfare, famine) and lower birth rates (abortion, birth control).
- Three-pointers** Carved triangular-shaped objects, normally in stone and typically found in two sizes: small (3 to 7 cm at base) and large (15 to 30 cm); small versions are usually undecorated while larger ones possess varied anthropomorphic and zoomorphic designs; considered to be *cemí*-imbued materials.
- Toponym** Place name, i.e. a name for any feature on a geographical map. The study of toponyms is called toponymy, which is a subbranch of onomastics, the study of any kind of names in human language.
- Trade winds** Predominant easterly wind patterns in the tropical areas of the earth.
- Transgression (marine transgression)** A geologic event during which the sea level rises relative to the land whereas the shoreline moves towards higher ground (land), resulting eventually in flooding. This can be caused by the sinking of land and/or ocean basins but also by severe climate change such as ice ages or isostatic adjustments. The opposite is called a marine transgression.
- Transported landscape** A landscape modified by humans with the introduction of non-native plant and/or animal taxa or through the remaking of a landscape by colonists to resemble their home environment.
- Tropophytic plants** Plants adapted to conditions in which periods of heavy rainfall alternate with periods of drought.
- Várzea** Flooded fluvial plain along the main Amazonian rivers that can be directly cultivated during the dry season. Fertile sediments are deposited during the wet season, when the plain is completely flooded. Cultivation of várzea sometimes carries the risk of crop destruction by floodwaters that arrive too early.
- Vertisol** A "self-inverting" soil formed on deep clays with high shrink-swell capacity.
- Wetland field** In the *Maya Lowlands*, wetlands were sometimes modified to improve agricultural potential, most typically by ditching to facilitate drainage, but sometimes by building up island fields.

White sand formation Large quartz sand depositions found in the hinterland of the Holocene and Late Pleistocene sand formations of the Guianas, and which are part of the Tertiary belt. The origins are still debated but are generally attributed to the Pliocene era. In Suriname they are denominated the *Coesewijne Series*, in French Guiane the *Série détritique de base* and in Guyana the “(Berbice) White Sand Series.”

Xeric A habitat or environment characterized by low levels of moisture.

Xeromorphic Relating to structural adaptations of xerophytes (plants that can survive in an environment with little liquid water) that help them store water and withstand drought.

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